



Z H O N E <sup>TM</sup>

**IMACS Product Book**

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# I. IMACS Product Overview

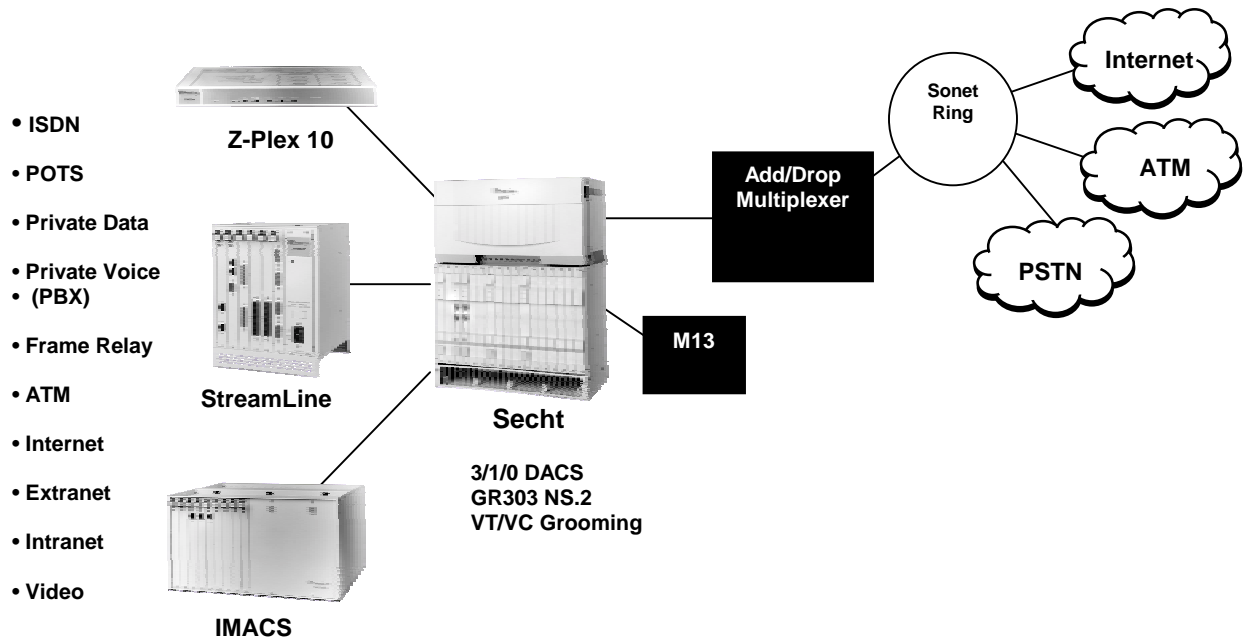
## IMACS

Zhone Technologies' Integrated Multiple Access Communications Server (IMACS) is a highly flexible and intelligent Integrated Access Device (IAD) that enables service providers worldwide to offer a wide variety of business communication services efficiently and cost-effectively. Services include Plain Old Telephone Services (POTS), analog private lines, Digital Data Networks (DDN), Frame Relay, Integrated Services Digital Network (ISDN), Asynchronous Transfer Mode (ATM) based services, high-speed Internet access and integrated routing. The IMACS supports V.35, V.11/X.21, HDSL, T1, E1, fractional T1, fractional E1 and DS3 network interfaces. For user connectivity, a variety of interfaces are available to support analog and digital devices.

An integrated Digital Cross Connect is available to consolidate multiple voice, data and T1/E1 services. In addition, IMACS offers a powerful array of built-in network diagnostic and fault isolation capabilities. These include built-in Bit Error Rate Testers, test tone and signaling state generation, digital and analog loop-back support and remote configuration and control. The Server slots on the IMACS platform enable provisioning advanced services such as voice compression (ADPCM and ACELP), ISDN call handling, Frame Relay switching and concentration, MCC and ATM adaptation.

Three types of IMACS chassis are available. The IMACS 600, IMACS 800 and IMACS 900 differ in their card capacity and front or rear card install options. All models support the same range of modular cards, power supplies and system redundancy options. All IMACS systems can be fully managed either with local craft interface with a VT100 or PC or through a network management system using SNMP.

The IMACS is a component of a complete line of managed, integrated access solutions from Zhone Technologies. Figure 1 shows how the service provider can deliver a complete suite of fast, efficient and reliable business communication services to the customers by deploying the Sechtor 300, IMACS, the StreamLine and the Z-Plex 10.



**Figure 1 - IMACS Product Family**

## **IMACS Features and Benefits**

### **Flexibility and Intelligence**

Global Standards Compliant—ensures product can be integrated in any international telecommunications network.

Provisioning for extensive array of services and applications—flexibility which enables providers to generate revenues without replacing existing equipment.

Concurrent support for Circuit, Packet, Frame, and Cell processing—single solution for service providers to use rather than purchasing and managing multiple boxes and networks.

Cost-effective migration path to emerging access services and technologies - investment protection.

SNMP Manageable—industry-wide accepted standard for network management a Remote software download capability—time and technical support resources savings.

### **Modular Architecture**

Ease of service and capacity expansion—preserves existing investment and reduces any need to forklift upgrade from old equipment.

Flexibility of provisioning technologies using multi-bus architecture- analog, digital, packet, frame, cell, etc.—enables carriers to offer various services and be a “one-stop” provider which generates more revenues.

Interchangeable set of User, WAN, and Server cards determine application set.

Well-designed chassis to fit into a variety of standard racks.

### **Powerful User Interface and Remote Management Capabilities**

Fully configurable through software—locally and remotely—eliminates need to send out technical support personnel to multiple sites, saving time and money.

Remote software upgrade capability on various cards—eliminates need to purchase new cards.

### **System Integrity Features**

Low power consumption.

Single chassis redundancy of power supply, CPU, network interfaces and converter.

Choice of clock synchronization sources with automatic clock fallback to alternate choice.

### **Ease of Maintenance and Enhancement**

Multiple maintenance ports for WAN, data and voice modules.

Extensive system-wide built-in diagnostics and fault isolation tests.

Continuous alarm monitoring.

Local and remote alarm logging.

Easy access to customer technical support.

Hot swappable cards.

## IMACS Architecture Overview

The IMACS chassis architecture supports three types of buses and five card types. The buses are the:

- User
- WAN
- Server

Communicating through the buses are the following five card types:

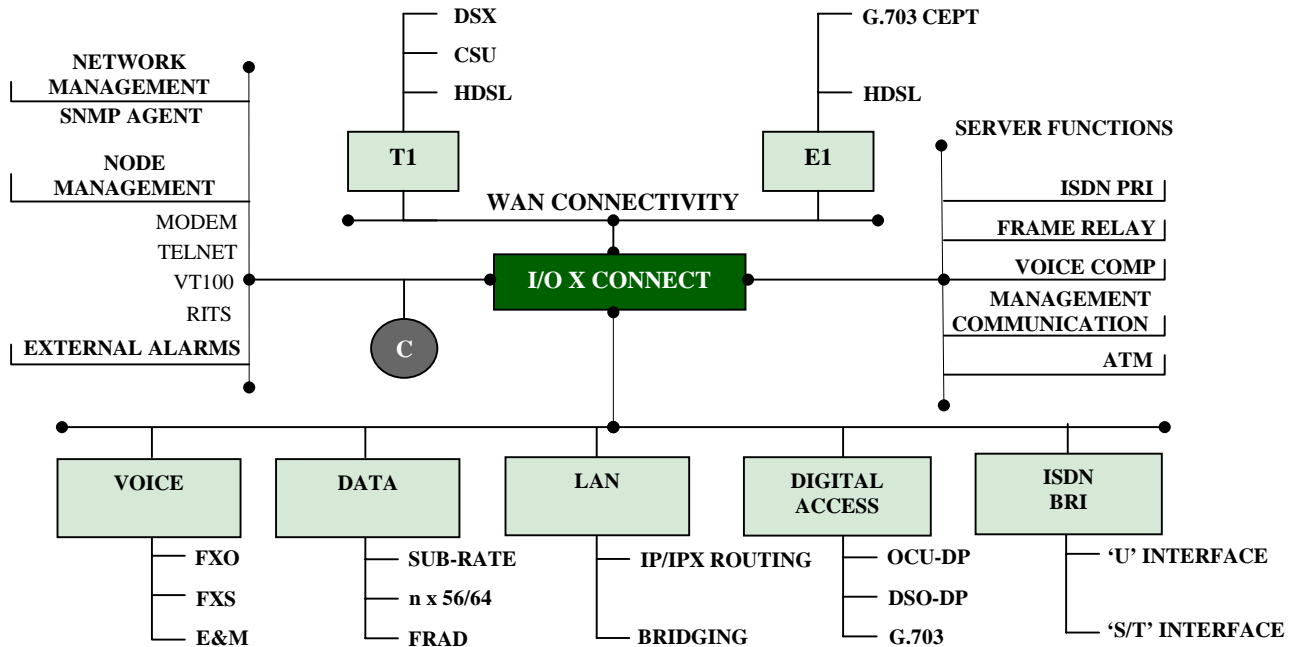
- CPU
- WAN
- User
- Server
- Interface

Each system has at least one CPU, WAN and one Interface card. These three cards provide common functions for the shelf. The WAN, User, and Server cards provide the specific voice/data terminal and network interfaces and processing required by the customer to transfer voice and data traffic from the customer premise to the network. IMACS architecture has specific card slots, which are tailored to provide either a WAN, User or Server function.

### IMACS System Bus Architecture

The IMACS is a multiprocessor-based platform that handles today's network access needs and provides a migration path to the wide range of services of the future. A unique multi-bus architecture provides this flexibility by off-loading and isolating the Wide Area Network (WAN) link processing tasks from those of inter-processor communications and channel I/O (input/output) control and signaling. The CPU card employs multiple communication buses extended through the back plane to the User, Server, WAN and Interface Cards. The CPU uses these buses to configure hardware on User, Server, WAN, or Interface cards and solicit status. Depending on the intelligence on the card, the CPU may either read or write to the card's hardware registers or send and receive messages using a messaging protocol.

This design approach yields two significant advantages over other access multiplexers. First, the off-loading of processing tasks across the multi-bus reduces system overhead, thereby improving the effective throughput and performance. Second, the isolation of functions allows rapid design and development of new network access compatible WAN functions. As the new functions are introduced, they occupy the Server card slot and do not impact or disrupt an existing system. For instance, the design of the Frame Relay Server card was performed utilizing the Server processor bus and is independent of other existing or future IMACS functions. When a Frame Relay server card is installed, it can perform Frame Relay access concentration on WAN links and fractional channels assigned to the IMACS. Figure 2 shows a functional block diagram of the IMACS's multi-bus architecture and the manner in which functions are isolated.



**Figure 2 - IMACS Architecture**

**User Buses**

The User buses are essentially a group of four Time Division Multiplexing (TDM) highways, each 2.048 Mbps in capacity, and named A, B, C, and D. They are utilized by the User cards to format their traffic for further processing either by Server or WAN cards. User cards are intended to provide physical interfaces to data or voice equipment that either resides on site or is remotely connected over low speed analog or digital facilities. Server cards may interface with these buses directly; whereas a cross-connect or bus connect CPU is required to interface the user buses to WAN cards.

IMACS Voice cards are designed to use the A and B buses only. When there are voice cards installed, the CPU allocates bandwidth on the A or B buses to these modules first. It then may utilize the remaining A and B bus bandwidth for any other User cards inserted into the shelf. Most Data Cards can be configured to use all 4 user buses.

**WAN Buses**

The WAN buses are a group of eight Time Division Multiplexing (TDM) highways, each 2.048 Mbps in capacity, and named W1-1, W1-2, W2-1, W2-2, W3-1, W3-2, W4-1 and W4-2, respectively. They are utilized by the WAN cards to format their traffic for transmission to high-speed digital facilities via the physical connector on the Interface card. A WAN link is typically a T1, CEPT-E1, DSX-1 or HDSL facility connection. There are four WAN card slots in an IMACS chassis. Each WAN card slot has 8 leads connected to the Interface card, which can be used to support a T1/E1 facility. The fourth WAN slot has all the WAN connections from the other 3 slots in addition to its own. These connections all terminate on the fourth WAN slot to support the WAN redundancy feature. The WAN in the fourth slot can substitute for one of the other WAN cards by connecting the redundant WAN card to the facility leads of the failed WAN card.



## Server Buses

The Server buses are all the buses that are accessible by the Server cards. Effectively this is the union of User buses and WAN buses. This enables the Server cards to provide a data processing function for WAN and User cards. The Server/Server card typically provides a centralized processing function on data initially entering the system from User or WAN connections.

A Server/Server card has the same highway interfaces as a CPU card with cross-connect functionality. A Server card can therefore function as a general cross-connect, or can rely on the cross-connect on the CPU, as needed by the application. The directions of the highways may be reversed, depending on whether a Server card is interfacing with User/WAN cards or with another CPU/Server card. For example, when a Server card is interfacing with User/WAN cards, it will drive the same TDM highways a CPU card normally drives. When interfacing to a CPU card it will drive the same TDM leads of a highway as a User/WAN card drive. When interfacing to another Server card, both cards may have to be programmed as to which highway lead to drive on and which to receive on. It may have to be able to drive and receive on both of the transmit and receive highways on a per time slot basis.

## Card Type Summary

The IMACS chassis architecture supports five basic types of cards. They are the Central Processing Unit (CPU) card, Interface card, Wide Area Network (WAN) card, User card and Server card. Each IMACS system has at least one CPU and WAN card and one Interface card. These three cards provide common functions for the shelf. The WAN, User, and Server cards provide the specific data terminal and network interfaces and processing required by the customer to transfer data from the premise to the network. IMACS architecture has specific card slots, which are tailored to provide either a WAN, User or Server function.

## CPU Card

The CPU is the “brain” of the IMACS and performs most of the configuration, management, and MIB and common processing for the IMACS. In addition the CPU card provides the interconnection of WAN, User, and Server TDM buses through a bus connect or cross-connect function. The IMACS can have up to 2 CPU cards, which provide a redundant control and switching complex. If the primary CPU fails, the standby takes over. A Mini-DACS 1/0 cross-connect for 256 DSOs is available.

## Interface Card

The interface card has common hardware, which is managed by the active CPU card. Configuration information processed on the CPU card is stored in the NVRAM on the interface card. It has interfaces to support a modem, control terminal, management port, printer, alarm relay, and provides the physical connection to the eight T1/E1 interfaces used by the WAN cards. The card also contains the clock hardware, which provides the entire back plane timing signals for the PCM buses. One Interface card is required per system.

## WAN Card

The WAN cards provide electrical interfaces to high-speed digital facilities, which are connected via the Interface card. The WAN cards take the voice and data traffic off the TDM bus, which was put there by the User and Server cards, and transmit the information over a WAN link. A WAN link is typically a T1, CEPT-E1, DSX-1, or HDSL facility connection. The WAN cards support a 1:N redundancy feature with Cross Connect CPUs only.

### **Voice Card**

The IMACS supports a wide-variety of cards to support voice channel bank applications. Typically they are a family of cards each of which provides 8 ports, which translate the analog signal to PCM and translate the signaling information from the analog interface for transmission over a digital facility. The interfaces supported include FXS, FXO, E&M, FXS Coin, FXO Coin and P-phone.

### **Data Card**

The IMACS supports multiple types of data cards for transport of Digital Data in 2, 4, 8 or 10 port models. They include High-speed synchronous V.35, EIA530, RS449, RS422, V.1 data, low speed RS232, V.24 data, DDS traffic (Digital Data via an OCU-DP or DSO-DP) and ISDN-BRI traffic.

### **Server Card**

The Server cards provide voice and data processing functions for WAN voice and User cards. The Server card typically provides a centralized processing function on traffic initially entering the system from User or WAN connections. The function is implemented, as a Server card when processing is needed on the data, following the termination of the physical interface layer. One example is protocol processing, where information needs to be extracted from a bit oriented protocol entering from one port, is processed, and sent out another port. The hardware function of the protocol processing is separated from the hardware required to support the physical interfaces. Traffic may arrive from time slots over a WAN link, or via an FXS card. An example is the ADPCM voice compression server card. The compressed voice data can be extracted from selected time slots of T1/E1 WAN links, and then expanded by ADPCM Server module. This can be accomplished without each WAN card having the hardware required to compress all its channels. Server cards can also be used to perform a high-speed trunking and aggregation function for the shelf. In these applications a Server card may have a high-speed cable or optical interface. An example of a high-speed aggregation function on a Server card is the ATM Server card, which has a high-speed DS3 interface. Other examples are the Frame Relay module for Frame Relay concentration, ISDN-PRI, Inverse-muxing, or Low Bit Rate Voice (LBRV).

### **Redundancy and Load Sharing**

IMACS supports load sharing and redundancy of the following critical system modules:

- System Power Supply Unit
- CPU Card
- WAN Card
- ADPCM Voice Compression Card

### **Power Supply Redundancy**

The IMACS Power Supply Units can support load sharing power redundancy and require the installation of two identical power supplies in the unit. The status of the power supplies is reported via LEDs that are visible through the front panel. Both IMACS power supplies load share in supplying all the power signals on a shelf. This includes 120/240 VAC, 24 VDC and -48VDC (when equipped). The IMACS power supplies are fully equipped with "ORing Diodes" on all power rails. Therefore, insertion and removal of power supplies are non-intrusive to system operation. Depending on system configuration, a single power supply can fully support the system. The main IMACS CPUs are also equipped with power supply monitoring functions. This capability enables the CPU boards to monitor the instantaneous levels of all voltages in the system. This provides immediate alarming of failed power supplies by the active CPU card.

### **CPU Card Redundancy**

The IMACS CPU cards typically support redundant operation when paired with an identical CPU card. The CPUs communicate with each other once every second. If there is a problem with the standby CPU (i.e., communications transfer did not take place), an alarm is raised by the active CPU, indicating a problem with the standby CPU. The active CPU monitoring is achieved via hardware watchdog timers on the Interface Card. The Interface Card's hardware timers are sensing specific control points from the controlling CPU circuit pack. These timers require only 8 seconds to detect and reset to the redundant blinking CPU card.

### **WAN Card Redundancy**

The IMACS Dual WAN cards in conjunction with a Dual WAN card with Relays support a 1-to-N redundancy. For redundant operation, the redundant WAN card will be located in the last WAN slot which is marked W4 and can be used in systems with cross connect CPUs to act as a redundant card for up to three Dual WAN cards containing the same modules. Both ports of the redundant card must be populated with either the DSX/CEPT or CSU module and must be an exact match to any corresponding WAN Cards with which it is redundant.

All IMACS WAN cards communicate with the active CPU card every half-second. If the WAN card fails to properly communicate with the active CPU card, the WAN card is declared failed and a switch occurs. These actions occur within an eight second time frame. The WAN card failures can also occur from craft defined rules. These rules are based on Carrier Group Alarm (CGA) declaration assignments. A CGA switch will occur 1.5 seconds after a CGA declaration, or forced "OOS" command from the User Interface (UI). The WAN card will remain in the switched condition for 20 seconds, or until synchronization can be achieved. If synchronization is not achieved, the WAN switch will return to its original state. If the switch is successful, the active CPU issues an alarm and the WAN switch continues in a steady state operation.

### **ADPCM Redundancy**

The IMACS Adaptive Differential Pulse Code Modulation (ADPCM) Server card provides 1-to-N redundancy when used with 2 other identical cards. The ADPCM card has on-board diagnostics that can detect a failure in one second, and switch in three seconds.

### **System Synchronization and Clocking**

The Interface card includes a Stratum 4 clock circuit, which is capable of running off its own crystal oscillator or phase locking to a 8 KHz reference clock on the back plane. Any card plugged into the back plane that connects to a network-like facility can be programmed to supply the reference clock input to the Stratum 4 Clock. As an option, a separate external timing source may be used on a specific interface card.

The IMACS supports a three-tiered hierarchy of system clocking sources that are provisioned under the interface card menu options. Should the Primary source fail, the system will fall back onto the Secondary source. Should both Primary and Secondary sources fail, the system will default to its internal Stratum 4 clock. In all cases, recovery is automatic should the failed clock(s) recover.

Both the Primary and Secondary clocks can be user-programmed to be derived from the following:

- IMACS system's internal oscillator.
- Any of the WAN interfaces in the system.
- A server card such as the ATM, which can provide timing through the DS3 link.
- A user card such as the BRI.
- An external synchronization device (framed T1 and unframed E1) through an 8922 I/F card.

The system will switch to the backup clock source upon detection of one of the following conditions in the currently active source:

- CGA Red Alarm.
- CGA Yellow Alarm.
- Out-Of-Service (OOS) condition.
- Clock source is placed in loop back mode.
- Clock source is placed in standby mode.

### **IMACS System Management**

When the IMACS' active CPU runs the IP protocol stack, it provides SNMP and Telnet support for management of local and remote IMACS units as well as provides for routing of IP datagrams to other IMACS systems. The Telnet protocol is a remote terminal protocol that allows any PC or workstation equipped with a TELNET client application to establish terminal sessions with an IMACS.

The Simple Network Management Protocol (SNMP) is a widely adopted industry standard method of providing common network management control. A typical SNMP management architecture involves a Manager, such as Zhone Technologies' Element Management System (EMS) product and an SNMP Agent, which is responsible for providing device management data to the manager. Agents come in two forms: Embedded and Proxy. Embedded agents run directly on the device being managed, while Proxy agents require an intermediate system to translate from a proprietary messaging format. The IMACS uses Embedded SNMP agents to report management information to the manager.

SNMP is a protocol standard that specifies how management data should be transported between an Agent and a Manager. SNMP MIBs (Management Information Base) specifies what comprises the management data. There are multiple MIBs that address many types of computer and telecommunications equipment. Some of these are defined as standards and are referred to by their RFC (Request For Comment) number. Other MIBs are specific to the device being managed and are referred to as Enterprise MIBs. The IMACS supports the following standard and enterprise MIBs:

- MIB-II (RFC 1213)
- DS1 MIB (RFC 1406)
- Alarm MIB (Traps to RFC 1215)
- Cross Connect MIB
- Frame Relay MIB RFC1604
- Frame Relay DTE MIB - RFC 1315
- MCC MIB
- ATM Forum UNI3.0 MIB
- DS3 MIB (RFC 1495)
- AToM MIB (RFC 1595)

Standard MIBs are written to provide management data on a wide number of devices, and in some cases not all of the parameters of a MIB are appropriate for the device being managed. Therefore extensions or omissions may be required in any standards based MIB.

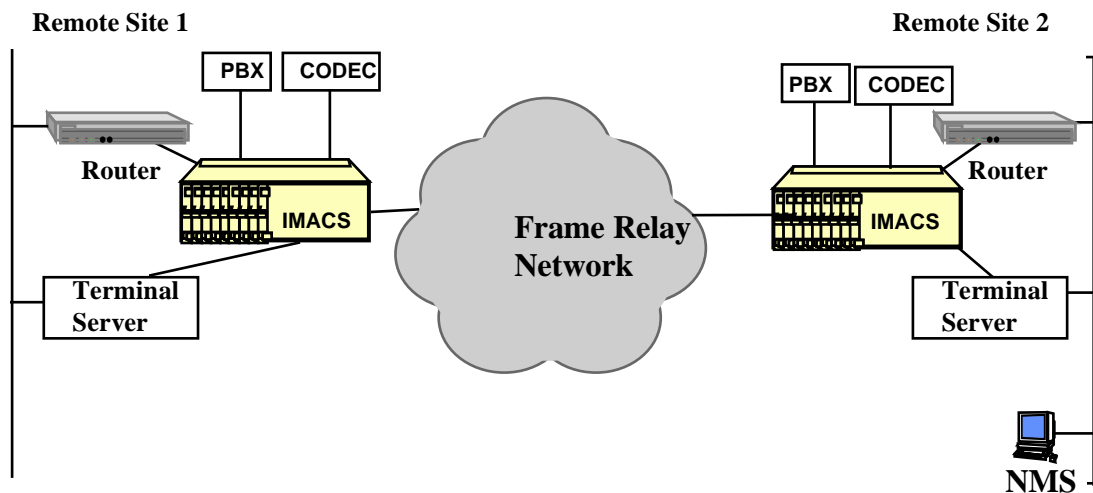
The IMACS offers several methods of transporting the SNMP and Telnet traffic from remote sites to the Network Management.

These methods include transport via:

- PPP or SLIP.
- FDL for T1 ESF mode or E1 National Bit 4.
- B7R Encoded Time Slots 24 (T1) or 31 (E1).
- Nx64 HDLC or FR available on CPU5.
- Frame Relay Management PVC.
- ATM Management PVC.

### IMACS Management Via PPP or SLIP

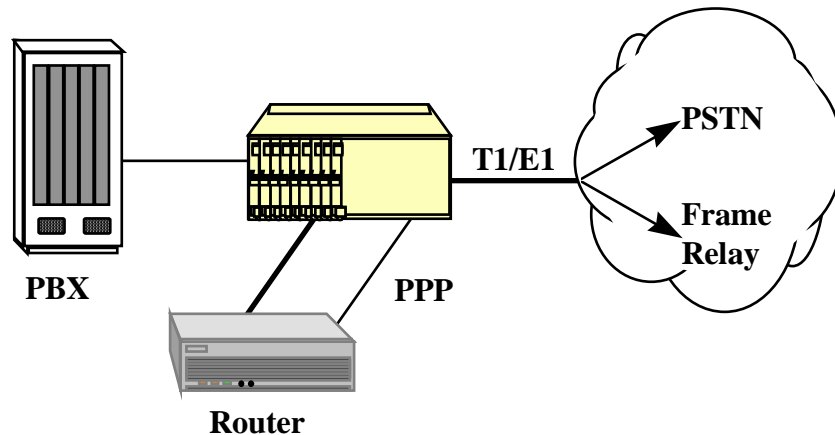
IMACS alarms are reported either to a local device or via an internal 2400 bps modem in a proprietary ASCII format to a central site. Additionally, the IMACS can be optioned to use TCP/IP and encode alarms as standard SNMP traps. One method of transmitting TCP/IP management information and SNMP traps is to activate the Serial Line Internet Protocol (SLIP) on the DB-9 port set at 9.6 Kbps. requires that a routed network exists and has full connectivity back to the location where the SNMP-based NMS resides. Figure 4 illustrates how terminal servers are used to provide connectivity from the IMACS' serial interface to the router-based network. A typical NMS scenario is described below:



**Figure 3 - IMACS Connectivity to Terminal Servers**

1. An alarm occurs in the IMACS on the left side of the diagram and an SNMP trap is sent out the serial port on the interface card.
2. A serial port of a Terminal Server that is configured for SLIP or PPP accepts the SNMP trap and forwards it over the Ethernet LAN.
3. The IP destination is the NMS; where it is picked up by the router for delivery to the NMS.
4. The router forwards the trap and other traffic destined for remote LANs, via its Frame Relay WAN connection. The router is connected through the IMACS to a Frame Relay network. The Frame Relay Network delivers the SNMP trap to the Operations Center on the right side of the diagram.
5. At the Operations Center, the IMACS, acting as a DSU/CSU, delivers traffic to the router.
6. The router places the SNMP trap onto the appropriate LAN where the NMS resides.
7. The NMS acknowledges and processes the trap. At this point an operator, noticing this new alarm, could initiate a TELNET session back to the originating IMACS or could browse the MIBs from the NMS.

As shown in Figure 4 the IMACS supports multiple methods of communicating SNMP messages and Telnet terminal sessions between an end node and the network management station. The addition of PPP support allows the IMACS to connect to routers or terminal servers to establish a connectivity path to the network management station. The utilization of PPP is similar to that of SLIP.

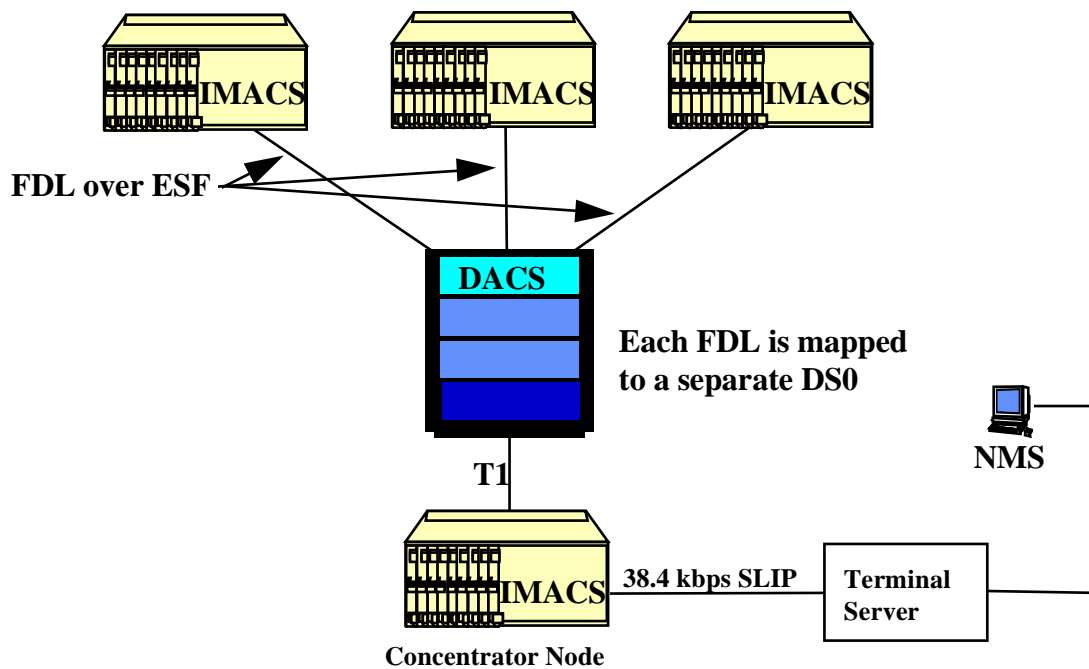


**Figure 4 - SNMP Messages and Telnet Sessions on IMACS**

#### **IMACS Management Using FDL/SA4**

Another method of transporting IP datagrams is via the Facility Data Link (FDL) on a T1 link using the Extended Super Frame (ESF) format. The FDL channel is a 4 Kbps channel available on the DS1 frame in the ESF overhead. The SA4 bits in the frame alignment word of the E1 constitute the equivalent for E1. This method requires that a DACS II is used in the central office, and is provisioned to extract the FDL / SA4 stream from the T1 /E1 and map it into a DS0 channel. DS0 channels from each remote node are then transported to an IMACS equipped with a B7R or MCC card so that IP datagrams can be extracted.

The use of the 4 Kbps FDL to carry management information across the network is illustrated in Figure 6. The remote IMACS at the top of the figure are terminated in a DACS II. The remote IMACS transport the TCP/IP management information across the FDL. The DACS II transforms the FDL channel into a DS0 channel using its proprietary B7R encoding scheme. These DS0s, carrying management information are combined with other DS0s carrying user information and arrive at the IMACS as shown in the bottom of the figure.



**Figure 5 - IMACS Management Using FDL**

The management DS0s are connected internally to the B7R card with a limit of eight management DS0s per card. The output of the B7R card is RS-232 at up to 38.4 Kbps using SLIP. This output is fed into a terminal server or a router and transported to a NMS. Alternatively, the SLIP Async stream can be connected directly into a locally attached NMS if a port is available. Furthermore, the MCC server card supports up to 128 remote connections.

#### **IMACS Management Using B7R encoded DS0 (TS 24 for T1 and TS 31 for E1)**

A third method is to carry IP traffic in a DS1's time slot 24 or E1's time slot 31. This method requires that each time slot 24/31 from multiple remote nodes are groomed in the network into a single T1, and are transported to an IMACS equipped with a B7R or MCC card so that IP data can be extracted.

A B7R card or a MCC card is used in the IMACS at the central site to accept and decode SNMP network management information from up to eight remote IMACS (via separate DS0s) (128 for MCC). The IMACS at the remote sites can place SNMP traps and other IP traffic in a B7R encoded DS0 (time slot 24/31). A B7R card is not required at the remote sites. At the central site a B7R/MCC card is required only if the B7R / DS0 transport mechanism is utilized.

The TCP/IP option must be available to support the B7R function. If the SNMP traps and associated TELNET sessions are carried in a B7R encoded DS-0 from the originating IMACS (instead of within the FDL), a DACS II is not required. In this case the NMS data from the originating IMACS is formatted by the remote IMACS's CPU in the same B7R format as would have been generated by the DACS II if the FDL scheme was used. In either case, a B7R or MCC card is required at the NMS concentrator site. The B7R card is a User card, therefore up to eight B7R cards may reside in an IMACS node, supporting eight DS0s each, for a total of 64 remote sites per IMACS. The MCC card is a server card, supporting up to 128 remote IMACS nodes. A total of 3 MCC cards are supported per concentrator node.

To manage the IMACS containing the B7R card, a separate SLIP/PPP connection from the DB9 on the interface card is required. The local IMACS cannot route its own SNMP information to an internal B7R card. For example, if a network has eight remote nodes, two SLIP connections are required at the central site - one for the eight remote IMACS and one for the local IMACS.

The Management Channel Concentrator (MCC) card allows management of the local system as well as 128 remote IMACS nodes. The remote systems may either be communicating using B7R on TS 24 (T1) or B4R on TS31 (E1) directly, via a cross-connect or be using FDL (T1) /SA4 (E1) with a DACS version 6.2 or equivalent. In addition, the MCC card has also four ports configurable with for a variable number of nx64 kbit DS0s. These can be used to forward already concentrated IP traffic down to a second MCC card.

Any SNMP manager can receive the SNMP trap and respond by initiating a TELNET session with the originating IMACS for diagnostics and control. Note that the local and remote reporting feature of the IMACS is disabled if the TCP/IP network management feature is active. The IMACS supports sending traps up to three SNMP trap servers, allowing alarms to be sent to multiple network management stations.

However, once the cards are installed and the chassis populated, these identifiers are no longer visible.



**a) E & M card with 2713 Hz Loop back – Module# 811760:**

This feature will provide digital loop back (both audio and signaling) when activated by a 2713 Hz tone of specified level and duration. The requirements are provided by BellCore PUB 42004. When a validated tone is detected the channel should disconnect the user and provide loop back of signals (audio and signaling) received from the network. The loop back must be performed without inserting any gain or loss in the path. After tone activation, the channel shall remain in the loop back mode unless deactivated for a period of 20 minutes (+/- 1 minute) after which the channel shall automatically revert to the idle (non loop back) mode.

**b) (Optional) P-Phone Line card with 8 ports (PPS Module# 812160 and PPO Module# 813160):**

The purpose of this feature is to provide an 8-port P-Phone Line card in the Streamline for Host 1.2. The P-Phone line card is used by Nortel to support transport of P-Phone service. There are two applications of the line card, one at the Office end (P-Phone Office – PPO), and one at the Station end (P-Phone Station – PPS). Hence, PPO and PPS are two user cards designed to support connectivity between a Nortel SL-100 PBX or DMS-100 based Centrex PBX and Nortel M5000 series Electronic Business Sets (P-Phones). The P-Phone is an electronic telephone set capable of supporting premium Meridian Digital Centrex (MDC) features offered by the local DMS switch. The data channel allows out-of-band signaling between the P-Phone and the DMS switch. This data channel allows the user to activate MDC features, such as conference calling by simply pushing keys on the P-Phone set, and for the DMS to deliver information, such as caller identification, to the P-Phone display. This P-Phone line card encodes the received out-of-band signaling tones, transports them across the carrier and decodes the digital representation back to out-of-band tones at the other end. Hence, this line card simply repeats the signaling end-to-end.

The market for P-Phones is by definition limited to Nortel switches and PBXs: DMS100 (Class 5 switch), DMS500 (Combination of Class 5 and a Tandem switch), DMS10 (Lower capacity switch for rural areas) and SL100 (Large Enterprise PBX).

P-Phones supported include: M5000 series business sets, models M5009, M5112, M5209, M5212 and M5312.

## II. IMACS Chassis and Common Equipment

### 1. IMACS Chassis and Back Plane

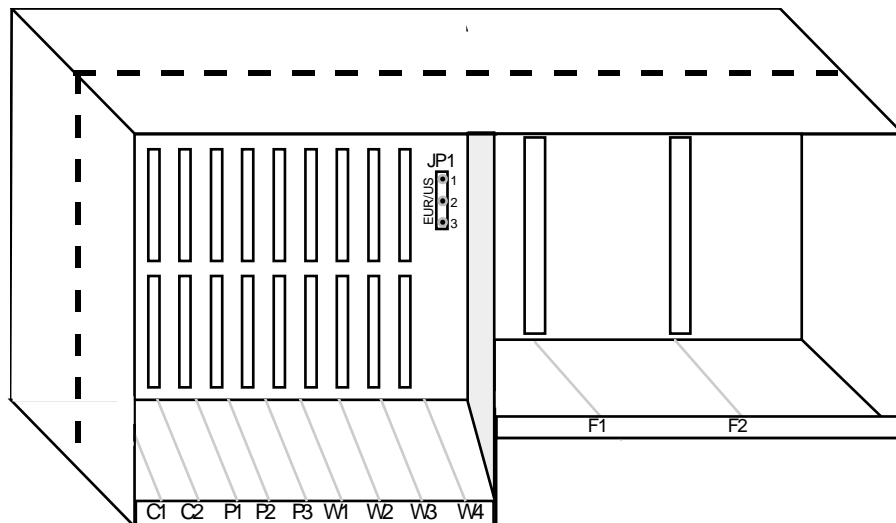
The IMACS is available in three chassis models to meet various space/capacity requirements. They are the IMACS 600 Universal Enclosure, the IMACS 800 Universal Enclosure and the IMACS 900 Universal Enclosure.

#### IMACS 800 Universal Enclosure

The IMACS 800 Universal Enclosure provides card slots on both the front and back of the unit for both front and rear loading. These are sometimes referred to as the “Network” and “User” sides respectively. There are nine card slots that are accessible from the front and an additional nine that are accessible from the back. Card slots are intended to accommodate specific card types and are keyed so that only those card types may be inserted in those slots. A CPU card may be inserted in either Slot C1 or C2. Two CPUs can be installed in Slots C1 and C2 simultaneously to provide CPU redundancy. All IMACS Universal Enclosure models are NEBS (TR63) approved.

The nine front card slots are allocated and shown in Figure 7 as follows:

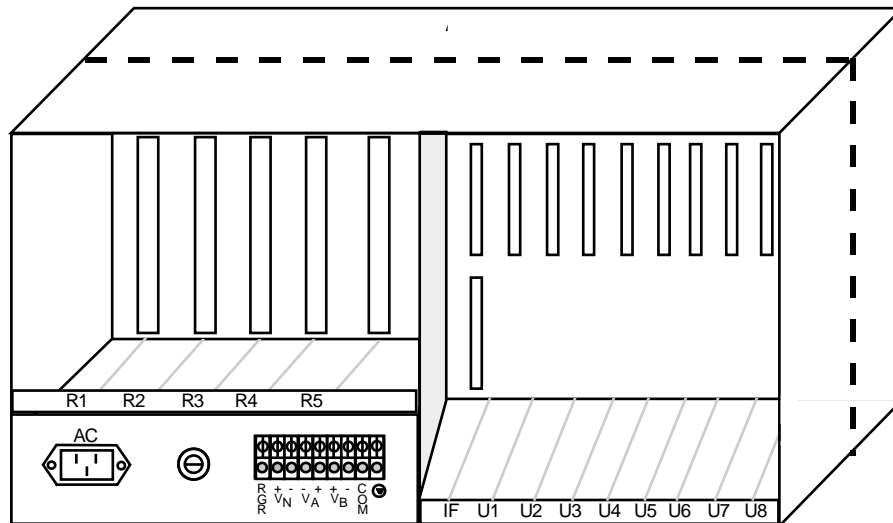
<u>Slot Number</u>	<u>Card Types Supported</u>
C1 and C2	CPU cards
P1, P2 and P3	Server cards
W1, W2, W3 and W4	WAN cards



**Figure 6 - IMACS 800 Universal Enclosure—Front View**

The nine back card slots are designated as IF and U1 through U8 respectively and are allocated and shown in Figure 7 as follows:

<u>Slot Number</u>	<u>Card Types Supported</u>
IF	Interface card
U1 through U8	Voice, Data and External Alarm cards



**Figure 7 - IMACS 800 Universal Enclosure—Rear View**

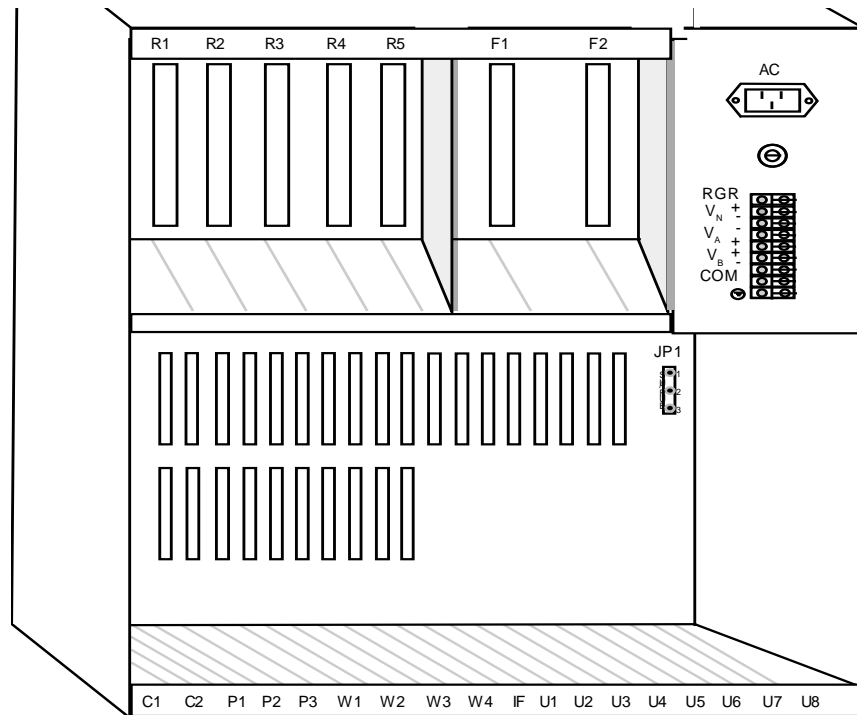
In addition to the card slots described above, the IMACS 800 chassis accommodates a power supply and ringing generator system. The power and ringing system can consist of up to two power supplies, two 120/240VAC-to-48VDC Converters, and up to three ringing generators. Five ringing generators can be supported in a system if there are no 120/240VAC-to-48VDC Converters installed. The maximum power consumption of an IMACS is 125 Watts. Power supplies are inserted into either of the two power slot positions (F1 and F2) from the front of the chassis.

The IMACS 800, 900 and 600 models support load sharing power redundancy. To achieve redundancy, the installation of two identical power supplies is required. The power supply status is reported via LEDs that are visible through the front panel. Alarm messages are generated when one of the two power supplies malfunctions or fails.

**IMACS 900 Universal Enclosure**

The IMACS 900 Universal Enclosure has the same capacity as and provides the same module slots in a front-loading only “repackaged” version of the IMACS 800 chassis.

There are nine slots that are referred to as the “Network” cards and an additional nine (9) that are “User” cards respectively. CPU card installation and slot allocation is the same as the IMACS 800. The nine network card slots are allocated the same as the IMACS 800 and are shown in Figure 9. The nine user card slots are designated as IF and U1 through U8 respectively and are the same as the IMACS 800.



**Figure 8 - IMACS 900 Universal Enclosure**

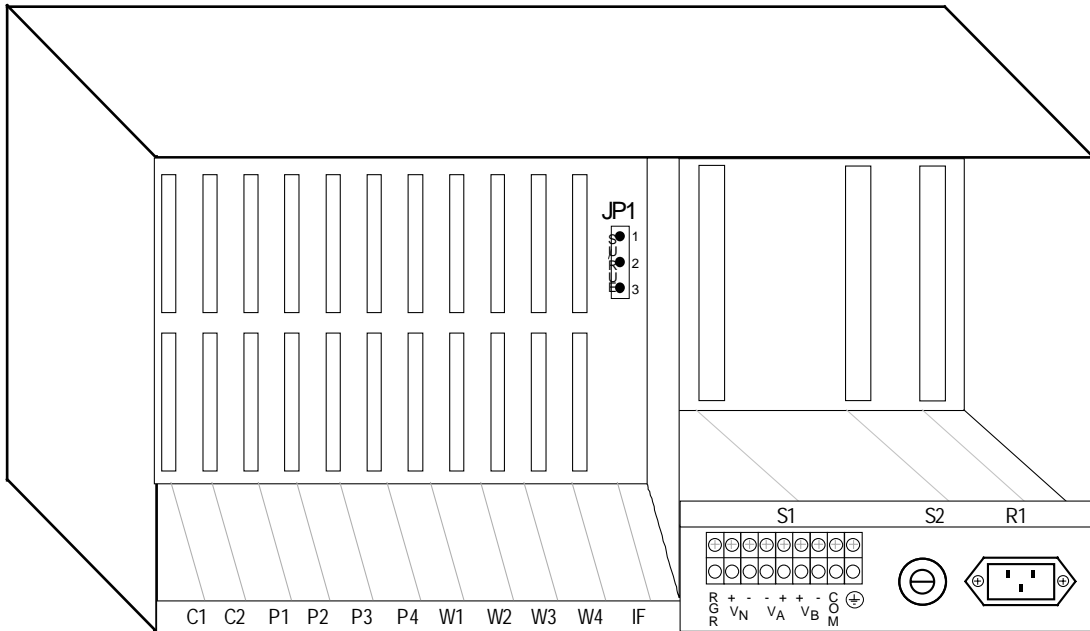
In addition to the card slots described above, the IMACS 900 chassis supports the same power supply and ringing generator system as the IMACS 800. Power supply loading is done the same way as the IMACS 800.

**IMACS 600 Front Load Enclosure**

The IMACS 600 Universal Enclosure provides card slots only on the front of the unit as shown in Figure 10.

This chassis is ideally suited for wall mount installations. In contrast to the IMACS 800 and 900 Enclosures (where User, CPU, WAN, and Server Cards were installed in the dedicated card slots), the IMACS 600 chassis allows user cards to be installed in any unused Server card or WAN card slot.

<u>Slot Number</u>	<u>Card Types Supported</u>
C1 and C2	CPU card
P1-P4	Any Server or User card
W1-W4	Any WAN or User card
IF	Interface card



**Figure 9 - IMACS 600 Universal Enclosure**

In addition to the card slots described above, the IMACS 600 Universal Enclosure accommodates two power supplies or one AC Power Supply, one AC-DC converter, and one ringing generator.

**Physical and Environmental Characteristics**

The IMACS Universal Enclosure dimensions are shown in Table 1.

**Table 1--IMACS Dimensions**

Chassis Model	Height		Width		Depth	
	in.	cm	in	cm	in	cm
600	9.120	23.16	17.042	43.29	9.131	23.19
800	9.120	23.16	17.042	43.29	15.300	38.86
900	15.375	39.05	16.918	42.97	9.105	23.13

The IMACS 600/800/900 can be mounted on:

- EIA 19" (482 mm) standard open rack
- Enclosed Cabinet or a WECCO 23" (584 mm) standard open rack
- Enclosed Cabinet (by using adapter ears)
- Wall-mounted (with 4 screws)
- Desktop

All the IMACS units are convection-cooled and require some minimum clearances for optimum operation. Clearance requirements also account for distance required for removal and insertion of cards from/into the chassis. The minimum clearances are shown in Table 2.

**Table 2—IMACS Minimum Clearances**

	<b>600</b>	<b>800</b>	<b>900</b>
Front	15" (38 cm)	15" (38 cm)	15" (38 cm)
Back	0" (0 cm)	15" (38 cm)	0" (0 cm)
Top	2" (5 cm)	2" (5 cm)	2" (5 cm)
Bottom	2" (5 cm)	2" (5 cm)	2" (5 cm)

In all cases, the unit must be installed in an environment that meets the following specifications:

AC power (120VAC):	90 VAC to 135 VAC
AC power (120/240 VAC):	175 VAC to 264 VAC
DC power (-48 VDC):	-42 VDC to -60 VDC OR -39VDC TO -60VDC
DC power (24 VDC):	20 to 32 VDC OR -18VDC TO 36 VDC
Power consumption:	125 Watts
Operating temperature:	0°C to 50°C (41°F to 121°F)
Storage temperature:	-20°C to 80°C (-4 °F to 176°F)
Operating Rel. Humidity:	5% to 85%

The IMACS Universal Enclosures conform to the following regulatory standards shown in Table 3.

**Table 3—IMACS Compliance With Regulatory Standards**

ANSI 310-D	Racks, Panels, and Associated Equipment
UL 459	Telephone Equipment
Bellcore GR-63-CORE	Network Equipment-Building System (NEBS), Level 3 Requirements: Physical Protections
Bellcore GR-1089-CORE, Issue 1	Electrical compatibility and electrical safety generic criteria for network telecommunications equipment
Bellcore TR-NWT-000295 Issue 2	Isolated Ground Planes: Definition and Application to Telephone Central Offices
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment
UL 1459	UL Standard for Safety of Telephone Equipment
CSA C22.2, No. 950, DOC CS03	Safety of information technology equipment including electrical business equipment
FCC Part 68 – Subpart B	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
IEC 297-1	Racks, Panels, and Associated Equipment
FCC Part 15	Subpart B

### Power Supplies

The IMACS has six power supplies and two ring generators, which can be installed or configured depending on the application. Power supply models 8901, 8902 and 8907 provide +/-5VDC and +/-12VDC. As shown in table 4, the main difference between these models is the input voltage.

Models 8903, 8905 and 8908 power supplies provide -48 VDC talk battery voltage from an AC input voltage. As shown in table 4, the difference between models 8903 and 8905 is the input voltage range. Model 8905 has a much wider input voltage range. Allowing it to operate from any AC line voltage, where as model 8903 has a limited range. Model 8908 can only be used with the 900 chassis. It also has the benefit of a wide input voltage range but with the addition of providing 300 watts of talk battery power.

**Table 4—Power Supply Specifications**

<b>Model 8901 AC Power Supply 120/240 AC</b>	
Input Voltage	Self-detecting, 90VAC to 135 VAC at 60HZ 175 VAC to 264 VAC at 50 Hz
Input Frequency	47 to 63 Hz
Inrush Surge Current	Max. 12 amp peak at 264 VAC cold start
Output Power	55W Continuous
Maximum Number per system	2
Redundancy	Optional
Ventilation	Convection cooled
Protection	Unit is fused and protected from short circuits and over-voltage
Approvals	UL 1459, EN 60950, CSA-C22.2 No.950, CE Mark
<b>Model 8902 DC Power Supply 48 VDC</b>	
Input Voltage	-39 to -60 VDC
Inrush Surge Current	Maximum 12 amp at 60VDC
Output Power	55 Watts Continuous
Maximum Number per system	2
Redundancy	Optional
Ventilation	Convection cooled
Protection	Unit is fused protected from short circuits and overage Unit is diode protected from reversed polarity
Approvals	UL 1459, EN60950, CSA-C22.2 No.950, CE Mark
<b>Model 8907 DC Power Supply 24 VDC,</b>	
Input Voltage	18 to 36 VDC
Inrush Surge Current	Maximum 12 amp at 36 VDC
Output Power:	55 Watts Continuous
Maximum Number per system	2
Redundancy	Optional
Ventilation	Convection cooled
Protection	Unit is fuse protected from short circuits and over-voltage Unit is diode protected from reverse polarity
Approvals	UL 1459, EN60950, CSA-C22.2 No.950, CE Mark
<b>Model 8903 Power Supply 120 VAC</b>	
Input Voltage	90VAC to 132 VAC
Input Frequency	60 Hz
Inrush Surge Current	Max. 20amp peak at 132 VAC cold start
Output Voltage	-48.0 VDC
Maximum Number per system	2
Redundancy	Optional
Ventilation	Convection cooled
Protection	Unit is fused and protected from short circuits and over-voltage
Approvals	UL 1459, UL 1950, CSA-C22.2 No.950

<b>Model 8905 Power Supply, 120/240 VAC</b>	
Input Voltage	90 Vrms to 260 Vrms
Input Frequency	50/60 Hz
Output Power	100W max
Output Voltage	-48.0 VDC
Output Current	2 amp
Maximum Number per system	2
Redundancy	Optional
Ventilation	Convection cooled
Approvals	UL 1459, UL 1950, CSA-C22.2 No.950, CE Mark
<b>Model 8908 Power Supply, 105/240 VAC</b>	
Input Voltage	90 Vrms to 260 Vrms
Input Frequency	50/60 Hz
Output Power	300 W max
Output Voltage	-48.0 VDC
Output Current	6.25 amp
Maximum Number per system	2
Redundancy	Optional
Ventilation	Forced Air, (120mm Fan)
Approvals	UL 1459, UL 1950, CSA-C22.2 No.950

**Ring Generator**

Ring generators are required to supply ringing current whenever there are Foreign Exchange Station (FXS) Cards operating in the unit or if there is one or more Foreign Exchange Office (FXO) ports that are used in Manual Ring Down (MRD) mode.

- The current ring generator model is: Model 890620

Model 890620, the internal ring generators, will support up to 24 simultaneously ringing phones. Additional ringers can be added depending on the chassis and application, (see table 5). The exact number of simultaneously ringing subscriber lines supported is a function of the Bell Ringer Equivalency Number (REN) of the attached devices and the loop impedance. The user may attach an external ring generator to the IMACS terminal block location marked RGR.

The model 890620 is an enhanced version of the current 8906 ring generator. This model has improved operating efficiency and inrush current limiting.

**Table —Ring Generator Specifications**

<b>Model 890620 Ringing Generator</b>							
Input Voltage	42 to 57 VDC, linear = 0.84 max.						
Efficiency	57% at 48 V and 1 kOhm load						
Protection	5 A slow blow fuse, primary current limiting						
Noise	Less than 32dBrc						
Output Voltage	100 VDC rms default – adjustable from 60 to 105 Vrms						
Output Current	160 mA RMS continuous, 230 mA RMS cadence						
Output Frequency	20 Hz +/- 1 Hz						
Operational Modes	Strap selectable: Master or Slave						
Maximum Number per system	<table border="0"> <tr> <td>IMACS 600</td> <td>1</td> </tr> <tr> <td>IMACS 800</td> <td>1 Master, 3 slaves (DC operation) 2 slaves (AC operation)</td> </tr> <tr> <td>IMACS 900</td> <td>1 Master, 1 slave</td> </tr> </table>	IMACS 600	1	IMACS 800	1 Master, 3 slaves (DC operation) 2 slaves (AC operation)	IMACS 900	1 Master, 1 slave
IMACS 600	1						
IMACS 800	1 Master, 3 slaves (DC operation) 2 slaves (AC operation)						
IMACS 900	1 Master, 1 slave						
Redundancy	There is no provision for Master Ringer redundancy, however the slave units provide fail-over protection						



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Ventilation	Convection cooled
Approval	UL 1459, CSA-C22.2, No. 950

## 2. CPU Cards

The CPU card has two micro-controllers, which performs most of the configuration, management, and common processing for the IMACS. The CPU card provides the interconnection of WAN/User/Server TDM buses through a bus connect or cross-connect function. The CPU can have flash memory which is used to store configuration information and facilitates new firmware uploads. The IMACS can have up to 2 CPU cards, which provide redundant control and switching capabilities. If the primary CPU fails, the standby takes over.

There are two microprocessors on the CPU card. The primary micro-controller on the CPU card does the configuration and maintenance functions for the IMACS. It is connected through an internal bus to all the Server/WAN/User cards and the Interface card. It controls the modem, database, serial terminal interfaces, and Stratum 4 clock configuration contained on the Interface card. The CPU is responsible for configuring the hardware residing on the cross-connect module (CCM), and configuring hardware on WAN/User cards. It is responsible for downloading configurations onto intelligent cards through the appropriate configuration interface. Finally, it accesses each WAN card to process FDL messages. The CPU provides control functionality, however it is the Interface card that stores the system configuration information.

The second micro-controller handles standard signaling processing for voice applications. It manages both the digital (bit-robbed) and the analog (48V) signaling capabilities of the IMACS. It has enough throughput and interfaces to handle the 62 voice channels routed through the A and B buses. The CPU receives signaling from each analog voice port and in turn processes the data and generates the appropriate signaling bits over the signaling highway to the WAN cards. The WAN cards then embed the signaling bits into the T1/E1 data stream. It also processes the signaling from the T1/E1 link to the User cards. The CPU can also customize the format of the signaling bits. This is an important feature when interfacing with a variety of central office switches and PBXs.

Additionally, the CPU card has an interface to the IMACS' time slot switching matrix. The switching matrix may either be a Bus connect (BCON) or Cross Connect (XCON). In the Bus connect configuration, the User bus ports can be connected to WAN bus ports but not the Server bus. When Cross-connect is used, all the TDM buses are brought up to the switching matrix, which is able to cross-connect time slots between the incoming and outgoing buses.

CPU cards can only be installed in the CPU slots. The shelf can be equipped with two CPUs, which form an active/standby pair. Watchdog timer circuitry on the Interface card helps monitor the active CPU and will activate the standby CPU if the active CPU fails. The active and standby CPUs communicate directly and the active can switch to standby by sending a single message. Additionally, a user can manually switch from the active to standby CPU by initiating a command from the VT-100 console. It is the CPU card, which initializes the system upon power-up and runs a self-test on all cards plugged into the system. After the initialization procedure, the CPU card continuously polls all cards in the system to determine their operating status. Table 7 provides detailed specifications on the five CPU models.

**Table 7—Operational Modes**

Model	Mode	Cross Connect	Drop and Insert	Terminate
880060	Bus-connect	No	Yes	Yes
880460	Enhanced bus-connect	No	Yes	Yes
880160, 880260, 880360	Cross-connect	Yes	Yes	Yes
<b>LED Indicators</b>		Green for normal operation. Amber for card fault or test mode (amber on new cards).		
<b>Code Storage</b>				
Models 880060, 880160, 880460		256K EPROM		
Model 880260		512K EPROM		
Model 880360		Configurable with maximum 8MB DRAM and 4MB Flash memory		
<b>Maximum number of WAN links</b>				
Model 880060		Up to 2 WAN links		
Model 880160, 880260, 880360		Up to 8 WAN links		
Model 880460		Up to 4 WAN links. WANs in slot W1 supports voice only operate in either Terminate or Drop and Insert mode. WANs in slot W3 operate in Terminate mode only and only terminate certain data ports.		
<b>Support for CPU redundancy</b>				
Model 880060		No		
Model 880160, 880260, 880360, 880460		Yes		
<b>Support for WAN link redundancy</b>				
Model 880060		No		
Model 880460		1:1—A WAN card in slot W2 provides backup for an identically configured WAN card in slot W1. A WAN card in slot W4 provides backup for an identically configured WAN card in slot W3.		
Model 880160, 880260, 880360		1:N—A single model 8014 WAN card in slot W4 provides backup for identically configured 8010 WANs in slots W1 through W3.		
<b>Support for Server Cards</b>				
Model 880060, 880460		No		
Model 880160		Only ADPCM Server card		
Model 880260, 880360		Support for all server cards		
<b>Standards Conformance</b>				
Bellcore GR-63-CORE		Network Equipment-Building System (NEBS) Requirements: Physical Protections		
CE EN 500 81-1		Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry		
CE EN 500 82-1		Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry		
CE EN 60 950/A2		Safety of information technology equipment including electrical business equipment		
UL 1950		UL Standard for Safety of Information Technology Equipment		
CSA C22.2, No. 950		Safety of information technology equipment including electrical business equipment		

### 3. Interface Cards

The Interface card has common hardware, which is managed by the active CPU card. One Interface card is required per system residing in Slot IF on the IMACS chassis. It provides the physical interface to support a modem, control terminal, printer, alarm relay, and provides the connection up to 8 T1/E1 interfaces used by the WAN cards. The card also contains the clock hardware, which provides the entire back plane timing signals for the TDM buses. The Interface card also contains the configuration database of the IMACS, time of day clock function and watchdog timer.

The database resides in non-volatile SRAM, which enables it to retain its information even when the card is unplugged or the IMACS is powered down. The IMACS has software configurable settings for both the primary and secondary system-timing clocks. If the primary clock fails, the system will automatically switch to the operator defined secondary clock source. The interface card contains the Stratum 4 clock hardware for providing internal timing. Other timing options include: timing off the WAN card; timing off an installed ATM server card and timing off an installed 826070 or 826171 BRI card. It also has an option for external timing from external synchronization clocks (892260 IF card).

The Interface card may have a Modem port that is used to connect an ITU V.22 internal dial modem to a standard telephone line. This port may be used either to log into the unit from a remote VT100 terminal or to send system alarms to a remote device. The modem port presents an RJ11 female connector.

The node port on the Interface card provides the form-C contact closure and the physical interface so that the Alarm Cut-Off (ACO) alarm may activate an external alarm system. The node port presents an RJ48 female connector with an RS485 electrical interface.

The Control Terminal port is used to connect a VT100 or compatible terminal to the IMACS system for node management and control purposes. The Control Terminal port presents an RJ48 female connector with an RS232 DCE electrical interface. The port is set to VT100 mode for asynchronous operation at 9600 bps with 8 data bits, 1 stop bit, and no parity. Also, the port supports an automatic log out feature after 15 minutes of inactivity.

The Computer Port connects a local device for printing alarms or can be configured to support SLIP for transport of SNMP management information or database configuration information. IMACS Release 5.x provides support of asynchronous PPP and SLIP. The computer port presents a DB9 male connector with an RS232 electrical interface.

The Interface card also stores ISDN Call profiles and signaling translation tables. All configuration information is stored on the Interface card NVRAM for non-volatile storage of system configuration. A copy of the system configuration is stored on the Interface card can be downloaded to the Flash memory on the CPU card. There are eight Interface card Models:

1. 892060 Eight port T1/E1 Interface Card, 2400bps modem
2. 892160 Eight port T1/E1 Interface Card, no modem
3. 892260 Eight port T1/E1 Interface Card, no modem, with external sync input
4. 892360 Eight port T1/E1 Interface Card, 2400bps modem
5. 892460 Eight port T1/E1 Interface Card, no modem (required for CPU 8803)
6. 892560 Two port T1/E1 Interface Card, no modem or DB9 port
7. 892660 Two port T1/E1 Interface Card, 2400bps modem
8. 892760 Two port E1 Interface Card, no modem

The 8920 Interface Card supports eight T1 or E1 WAN links, via a 50-pin Amphenol connector. The card has a DB-9 serial port for network management and two RJ48 jacks: one for an RS 485 node port and one for an RS-232 VT-100 control terminal port. There is a RJ-11 modem port as well. It supports eight T1 or E1 WAN links. The

892160 Interface Card is the same as the 892060 Interface card with the exception of the modem and can be used with the 880060, 880160 and 880460 CPU cards.

The 892260 Interface Card is similar to the 892460 except there is an external synchronization option, no node port and the DB-9 serial port is a DTE-male type. The external synchronization option is for support of up to 8 T1 Framed or E1 Unframed signals and this card can be used with the 880260 and 880360 CPU cards.

The 892360 Interface Card supports eight T1 or E1 WAN links, via a 50-pin AMP connector. The card has 128KB of NVRAM, a DB9 serial port for network management and three RJ48 jacks that connect to the modem, nodal port and VT-100 control terminal port.

The 892460 Interface Card supports the same functionality as the 892360 Interface card except that it has no internal modem port. It requires an 880360 CPU and 5.X.Y CPU firmware.

The 892560 Interface card supports one or two T1 or E1 WAN links via 2 RJ-48 jacks and includes a single RJ-48 jack for a VT100 control terminal. Additionally, two sets of Bantam jacks are available for monitoring each WAN. This interface card does not support WAN redundancy.

The 892660 Interface card supports one or two T1 or E1 WAN links via 2 RJ-48 jacks. The 892660 includes a single RJ-48 jack for a VT100 control terminal, an RJ11 port for an internal 2400 bps, and a DB9 port. Additionally, two sets of Bantam jacks are available for monitoring each WAN. This interface card does **not** support WAN redundancy.

The 892760 Interface card supports two E1 WAN links via 2 BNC connectors. The 892760 includes a single RJ-48 jack for a VT100 control terminal, an RS 485 Node Port and a DB9 port. Table 8 provides a detailed list of the Interface Cards' specifications.

**Table 8—Interface Card Specifications**

Model 892xxx Interface Cards		Configuration Storage		CPU Host Firmware compatible		
Models 892060, 892160, 892560, 892660 and 892760		32KB NVRAM		3.x.y		
Models 892260, 892261, 892360 and 892460		128KB NVRAM		4.x.y, 5.x.y		
Interfaces						
Model	T1/E1 Links	Computer Port (DB-9)	Control Terminal Interface Port	Node Port	Internal Modem	External Sync
892060	8 T1/E1	YES	YES	YES	YES	NO
892160	8 T1/E1	YES	YES	YES	NO	NO
892260	8 T1/E1	YES	YES	YES	NO	YES
892261	8 T1/E1	YES	YES	YES	NO	YES
892360	8 T1/E1	YES	YES	YES	YES	NO
892460	8 T1/E1	YES	YES	YES	NO	NO
892560	2 T1	NO	YES	YES	NO	NO
892660	2 T1	YES	YES	NO	YES	NO
892760	2 E1	YES	YES	YES	NO	NO
WAN Ports						
Electrical Interface				G.703 or DSX-1		
Model				Connector Type		
892060, 892160, 892260, 892261, 892360 and 892460				One Female 50-pin RJ-27X Telco connector		
892560 and 892660				Two Female RJ-48 connector		
892760				Two Pair Female BNC connector		
All Models prior to Rev CO				DB9F DCE (requires 1201 cable)		
All Models from Rev CO				DB9M DTE (requires 1202 cable)		
Electrical Interface		RS-232, ITU-T V.28				
Function		Connects to local Element Management System				
Code Set		8 bit characters plus one start and one stop bit with no parity				
Max Speed		19.2Kbps (PPP) or 9.6Kbps (SLIP)				

**Table 8—Interface Card Specifications (continued)**

<b>Control Terminal Interface Port</b>	
Connector	RJ-48F, 8 pin, EIA 561
Electrical Interface	DCE RS232, ITU-T V.28
Function	Connect local VT100-compatible Control Terminal (local craft interface on the 892260)
Speed	Maximum 9,600 bps asynchronous
Code Set	8 bit characters plus one start and one stop bit with no parity
<b>Node Port</b>	
Connector	RJ-48F, 8-pin
Electrical Interface	Dry contact
Alarm Output	Passive current loop, one normally open loop and one normally closed loop
Function	Alarm management between co-located IMACS nodes and external alarm management systems and panels
<b>Modem Port</b>	
	Models 892060, 892360, 892660 only
Connector	Female 6-pin RJ-11c socket
Electrical Interface	600 ohm 2-wire balanced
Protection	HV zener, 0.25A fuses on Tip and Ring
Function	Connect internal modem to PSTN for access to remote operator and remote EMS network management system
<b>Modem Specifications</b>	
	Model 892060, 892360, 892660 only
Compatibility	ITU-T V.22 bis
Modulation	16 point QAM
Line interface	2-wire balanced 600 ohm
Ringer Equivalence	0.2 A
Approval	FCC Part 68
Equalization	Receive automatic adaptive, transmit fixed compromise
Transmit Level	-9.5 dBm
Receiver Sensitivity	On to OFF threshold -4.5dBm, OFF to ON threshold -48 dBm
Dialing Mode	DTMF Tone
Speed Supported	2,400 bps asynchronous
Code Set	8 bit characters plus one start and one stop bit with no parity
<b>Adapters</b>	
Model 1106 with 2 BNC connectors	Supports 1 E1 circuit on 75 ohm coaxial cable (RG59)
Model 1121 with 2 RJ48 sockets	Supports 2 T1 or E1 circuits on twisted pair cable plus bantam jacks for test
Model 1181 with 8 RJ48 sockets	Supports 8 T1 or E1 circuits on twisted pair cable
Model 1184 with 16 BNC sockets	Supports 8 E1 circuits (suitable for IMACS 800)
<b>Standards Conformance</b>	
ITU-T V.28	Electrical characteristics for unbalanced double-current interchange circuits
ITU-T G.703	Physical/Electrical Characteristics of Hierarchical Digital I/F
ITU-T V.22 bis	2400 bits per second Duplex Modem Using the Frequency Division Technique
EIA 56	8-Position Non-Synchronous Interface between DTE and DCE Employing Serial Data Interchange

**Table 8—Interface Card Specifications (continued)**

EIA RS232-C	Interface between DTE and DCE Employing Serial Binary Data
Bellcore GR-63-CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protections
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CEN EN 60 950/A2	Safety of information technology equipment including electrical business equipment
FCC Part 68 DOC CS03	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
UL 1459	UL Standard for Safety of Telephone Equipment
UL 1950	UL Standard for Safety of Information Technology Equipment
CSA C22.2, No. 950	Safety of information technology equipment including electrical business equipment

#### 4. WAN Cards

The WAN cards manage the flow of data through the integrated access system network. It provides the logical and electrical interface to high-speed digital facilities, which are typically physically connected via the Interface card. WAN cards take the data off the bus, which was put there by the User and Server cards, and transmit the information over a WAN link. A WAN link is typically a T1, E1, DSX-1, or HDSL facility connection. This WAN link can be either user or network link. In combination with the CPU card, the WAN card provides E1 to T1 and T1 to E1 conversion.

The WAN Cards also provide performance statistics. They are stored in memory on the IMACS' host CPU card and retrieved upon command. The performance statistics are gathered and displayed in 15-minute intervals and retained for 24 hours. In the T1 environment, an error is defined as any CRC-6, Controlled Slip, or Out of Frame (OOF) error for ESF framing, and any Bipolar Violation (BPV), Controlled Slip, or OOF error for the D4 format. In an E1 environment, an error is defined as any CRC-4 error, Controlled Slip, or OOF error.

In the AT&T mode, two sets of registers (user and network) accumulate performance data for T1 WAN links. It is possible to view both the user and network registers, but the end user can only clear the user registers. The network only has access to the network registers, and can only clear those registers. The ANSI and E1 WAN links have only one set of registers.

For further information regarding performance, and integrated test capabilities such as loop backs, BERT Tests and Signal Quality please see Section 13, IMACS System Testing and Diagnostics.

Each port on the WAN cards can be individually configured with DSX/CEPT or CSU plug-in modules. Both CSU and DSX modules are used to connect to T1 facilities operating at 1.544 Mbps. The CEPT module is used for connection to a 2.048 Mbps E1 facility. All WAN interfaces comply with the appropriate North American and international standards. Those cards equipped with CSU or DSX/CEPT modules also act as the "near end" termination points for the Subscriber Loop Carrier (SLC-96) facilities defined in BellCore publication TR-TSY-000008, Issue 2, August 1987. Each WAN card can operate in dual channel bank, drop and insert, or full digital cross-connect mode and can perform T1-E1 conversion, including PCM A-Law to  $\mu$ -Law conversion. When fully populated with 4 dual WAN cards, the IMACS supports 8 T1 or E1 connections, in any combination of T1 (DSX1 or DSX1 with CSU), E1 (CEPT) and HDSL interfaces.

The DSX/CEPT and CSU Modules are used to connect to T1 facilities, which operate at 1.544 Mbps. The CEPT function of the DSX/CEPT module is used internationally for connection to a 2.048 Mbps E1 network. The HDSL module provides a high-speed digital subscriber line (HDSL) interface.

Each WAN card slot has eight leads connected to the Interface card slot, which can be used to support facility interfaces. The last WAN slot has all the WAN connections from the other three slots in addition to its own to support the WAN redundancy feature. The WAN card in the last slot can substitute for one of the other WAN cards.



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There are four highways dedicated to the WAN slot, which are used to carry TDM data and signaling. Each WAN slot is connected to the Interface card through the back plane.

The IMACS supports *six* models of WAN cards:

1. 800060 Single T1/E1 WAN card
2. 801060 Dual T1/E1 WAN Card
3. 801460 Dual T1/E1 WAN Card with Relays
4. 801160 Dual E1 HDSL WAN Card
5. 801560 Dual T1 WAN card with ESF loop back
6. 802060 PairGain HDSL T1 WAN Card

The 800060 Single T1/E1 Link Card is the basic WAN Card. It has a single port for DSX/CEPT or CSU modules.

The 801060 Dual T1/E1 WAN card has two ports for either DSX/CEPT or CSU operation or a combination of the two. Both ports of this card must be populated with either the DSX/CEPT or CSU module.

The 801460 Dual T1/E1 Link Card with Relays can be used in systems with Cross Connect CPUs to act as a redundant card (1:N redundancy) for up to three standard WAN cards. Both ports of this card must be populated with either the DSX/CEPT or CSU module and must be an exact match to any WAN Cards with which it is redundant.

The 801560 WAN card with ESF Loop back is able to detect ESF data link codewords for line and payload activate and deactivate commands and the universal loop back deactivate command. A minimum reception of 10 continuous command patterns by each channel is required to trigger the loop back detection process, and the performing of the command. Since all 8 channels (4 WAN cards) are processed by one processor on the CPU card, simultaneous detection on more than one channel requires more than 10 repetitions.

The 802060 Pair Gain HDSL WAN is a dual WAN card designed to support the North American (T1) market using the PairGain HDSL OEM module (HOM). This also supports 4:1 redundancy as well as user configurable HRU functionality relative to HDSL timing. The IMACS can support up to four (4) 802060 WAN cards simultaneously and can be configured, monitored and tested through the IMACS craft interface and/or through the SNMP MIB interface. This design supports two PairGain HDSL modules per card for either IMACS to IMACS configurations as well as IMACS to PairGain NTU configurations. Each module may be configured as primary or subordinate. There must be one primary and one subordinate in the circuit. The unit designated as the primary can be accessed to change system parameters and view HDSL system performance history and current status. The subordinate provides HDSL system performance history and current status. The subordinate unit receives configuration parameters from the master unit at the other end of the loop. These configuration parameters include: Timeout for loop back, DS1 line code option (e.g. B8ZS/AMI), DS1 framing format (e.g. SF/ESF). The 802060 HDSL WAN module is supported by IMACS HOST 5.1 (or greater).

For connection to T1/E1 facilities, a DSX/CEPT or CSU Plug-in module is required per WAN port. The available modules are:

- 811 T1-DSX/E1-CEPT Plug-in Module (transmission range is 655 ft.)
- 812 T1-CSU Plug-in Module (transmission range is 3000 to 6000 ft)
- 82030 2\*1168Kbps E1 HDSL Module (compliant with ETSI ETR-152)
- 82100 Dual T1 HDSL Module

These plug-in modules are mounted on the WAN cards for operation. The 811 T1-DSX/CEPT plug-in module supports either DSX or CEPT modes. Jumper / shorting pin settings on the module specify DSX or CEPT operation. The 812 CSU plug-in module is required for T1 Channel Service Unit (CSU) operation. It can be operated in D4, ESF, SLC96 or SLCD4 mode.

The 801160 Dual E1-HDSL WAN Card has two ports that are equipped with E1-HDSL modules from ADTRAN. The HDSL modules provide 2.048 Mbps E1 transmission over 2 copper pairs. It provides transport of data at an E1 rate over copper cable without mid-span repeaters or conditioning. For connection to copper loops, one HDSL module is required per WAN port.

The 802060 Dual T1 HDSL WAN Card has two ports that are equipped with 82100 T1 HDSL modules. The HDSL modules provide 1.544 Mbps T1 transmission over 2 copper pairs. Both modules have to be installed for proper operation and do not support redundancy. Table 9 depicts the various T1/E1 WAN card specifications. In addition to the specifications listed in Table 9 (below) the 802060 card is in conformance with ITU-T Q.421 and ITU-T Q.422. The transmission range is software selectable for the following: 0, 133, 266, 399, 533 or 655 ft. (up to 200 meters), and CSU (allowing connections to the equipment side of a co-located external CSU over a short distance, four-wire cable). Software selectable line build out (LBO) settings are also available for all of the aforementioned transmission ranges.

**Table 9—WAN Card Hardware Specifications**

Model	Number of Ports	Number of Cards	Physical Interface	Electrical Interface
800060	1	1 to 4	Through 892xxx I/F card	811 (T1-DSX/E1-CEPT) 812 (T1-CSU) - 1 per port
801060, 801460	2	1 to 4	Through 892xxx I/F card	811 (T1-DSX/E1-CEPT) 812 (T1-CSU) - 1 per port
801560	2	1 to 4	Through 892xxx I/F card	811 (T1-DSX/E1-CEPT) 812 (T1-CSU) - 1 per port
802060	2	1 to 4	Through 892xxx I/F card	82100 is used to provide 1 T1 HDSL interface
801160	2	1 to 4	Through 892xxx I/F card	82030 provides 2*1168Kbps E1 HDSL module. Required for each port.
<b>T1 Signal Format</b>				
Electrical Interface		ANSI T1.102/T1.403, DSX-1, balanced 100 Ω		
Frame Format		D4, ESF, Subscriber Loop Carrier (SLC) 96, SLCD4		
Line Coding		AMI or B8ZS		
Signaling		AT&T 43801, 62411, ITU-T, Q.421, Q.422 using Robbed-bit method		
Error Detection		CRC-6, Controlled Slip, Bipolar Violation, Out of Frame		
Alarm Indication		BellCore TR-TSY-000191		
SLIP Limit		126 bits or 138 bits		
Bit Rate and Tolerance		1.544Kbps +32PPM. Jitter complies with ANSI T1.403		
<b>E1 Signal Format</b>				
Electrical Interface		G.703 balanced 120 Ω or unbalanced 75 Ω		
Coding		HDB3		
Framing		ITU-T G.704 Timeslots consist of 8 bits. Frame consists of 32 time slots, Multi-frame consists of 16 frames		
Signaling		CAS, CCS In Timeslot 16 if required. CAS Signaling protocols: AT&T 43801, 62411, ITU-T Q.421 (2)		
Error Detection		CRC-4, Controlled Slip, Out of Frame		
Alarm Indication		ITU-T G.732		
<b>Performance and Test Options</b>				
Loop backs		Line, local, channel, loop back generation and detection		
T1		FDL in accordance with AT&T 54016 or ANSI T1.403 (8015 only)		
E1		National Bit Supporting (G.704)		
<b>Standards Conformance</b>				
AT&T TR43801		Digital Channel Bank Requirements & Objectives		
AT&T TR54016		Requirements for Interfacing Digital Terminal Equipment to Service Employing the Extended Superframe Format		
AT&T TR62411		Accunet T1.5 Service, Description and Interface Specifications		
AT&T TR41449		ISDN Primary Rate Interface Specification		
BellCore TR-TSY-000008		Digital Interface Between the SLC 96 Digital Loop		
BellCore TR-TSY-000191		Alarm Indication Signal, Requirements and Objectives		

**Table 9—WAN Card Hardware Specifications (continued)**

ANSI T1.101	Synchronization Interface Standards for Digital Networks
ANSI T1.107	Digital Hierarchy - Formats Specifications
ANSI T1.403	ISDN, Network-to-Customer Installation -DS1 Metallic I/F
ANSI T1.408	ISDN Primary Rate
FCC Part 68	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
ITU-T G.703	Physical/Electrical Characteristics of Hierarchical Digital I/F
ITU-T G.704	Synchronous Frame Structure Used at Primary and Secondary Hierarchical Levels
ITU-T G.735	Characteristics Of Primary PCM Multiplexed Equipment Operating at 2048 Kbps and Offering Synchronous Digital Access At 384 Kbps and/or 64 Kbps
ITU-T G.732	Characteristics of Primary PCM Multiplexed Equipment Operating at 2048 Kbps
ITU-T G.736	Characteristics of A Synchronous Digital Multiplex Equipment at 2048 Kbps
ITU-T G.823	The Control of Jitter and Wander Within Digital Networks Which Are Based on the 2048 Kbps Hierarchy
ITU-T G.824	The Control of Jitter and Wander Within Digital Networks Which Are Based on the 1544 Kbps Hierarchy
Bellcore GR-63-CORE Issue 1	Network Equipment-Building System (NEBS) Requirements: Physical Protections
Bellcore GR-1089	ESD Sec 2, EMC Sec 3,
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 550-22	EMI Level B
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment
UL 1950	UL Standard for Safety of Information Technology Equipment
ETSI ETR 152	High Bit Rate Digital Subscriber Line Transmission
CSA C22.2, No. 950	Safety of information technology equipment including electrical business equipment

### III. IMACS Voice Modules and Applications

#### 1. Foreign Exchange Station (FXS) Card

The IMACS supports one Foreign Exchange Station (FXS) card, the 812960 FXS Card, which provides eight 2-wire analog ports with a terminating impedance of 600 ohms.

FXS cards can be installed in any IMACS chassis User Slot, and will (in most cases) require a ring generator. AC powered systems will also require a –48 VDC converter. FXS cards encode the incoming analog voice signals into 64 Kbps PCM format before transmission onto the network. Each FXS card provides a single 50-pin female amphenol connector (RJ27X).

All port parameters are software configurable on a port-by-port basis. The Mode setting specifies whether the port is to be used for standard Foreign Exchange Station, Foreign Exchange Software Defined Network (“wink”), Private Line Automatic Ringdown (PLAR), or Dial Pulse Origination applications. For example in the case of a PLAR circuit, the port can be programmed to provide Ringback Tone towards the caller. The Type setting specifies Loop Start, Loop Start with Forward Disconnect, Ground Start, Ground Start Immediate and Ground Start Automatic operation. If the PLAR mode is selected, then the two options supported under Type are “D3” and “D4” which meet the pre-1988 and post-1988 specifications for PLAR circuits. The PCM Coding options supported include  $\mu$ -Law, A-Law and inverted A-Law, and the user may also select the Trunk Conditioning mode (busy or idle) that should be applied towards the attached equipment should the WAN facility that the port is connected to fails. In addition, both the Transmit (Tx) and Receive (Rx) TLP levels can be set in increments of 0.1 dB. The Tx TLP range is from -10.0 dB to +5.0 dB. The Rx TLP range is from -10.0 dB to +2.0 dB.

The user may also specify, on a port-by-port basis, whether to use North American ANSI standard ABCD signaling (which is the default) or ITU (CCITT) ABCD signaling by turning the signaling conversion setting “on” or “off”. The trans-hybrid balance may be specified as one of eight values as well as for a customized user-specified terminating impedance. At the present time, all eight values are identical and are set for a terminating impedance of 600+2.15 $\mu$ F in the case of a Model 8129 FXS card.

Software-initiated testing and diagnostics supported on FXS cards include the setting of both analog and digital loop back towards the network and the generation of a Digital MilliWatt (DMW) signal on a port-by-port basis. A robust set of Test functions allow the user to monitor and set the state of the analog Tip and Ring leads of any FXS port and to set and monitor the state of the ABCD signaling bits of the digitized voice signal. In cross-connect systems, the Test functionality also includes the ability to generate test tones (300Hz, 1 kHz, 3 kHz and “quiet”) and transmit those toward either the user side or the network side of the system. FXS cards can use the voice-compression features of the ADPCM and LBRV Server cards. Table 10 provides all the relevant FXS cards specifications.

**Table 10—FXS Specifications**

<b>Model 8129 2-wire Analog FXS Voice Card</b>		
<b>Physical Characteristics</b>		
Model 812960	8 ports	
Physical Interface	1 female 50-pin Telco connector	
Dimensions of Card	8 x 0.94 x 7.48 inches (HWD)	
Weight of Card	1 lb or .4 k	
Power Consumption of Card	3.12 W	
Signaling Modes	Software configurable on a per port basis: foreign exchange station (FXS), FXS defined network (Megacom), Private Line Automatic Ringdown (PLAR), Dial Pulse Originating (DPO)	
Signaling Types	Loop Start, Ground Start, Loop Start with Forward Disconnect, Feature Group D (for high-speed modem services), Bill On Answer, D3, D4, DPO and Single Party, Universal Grade Voice	
<b>Specification</b>	<b>Short Loop</b>	<b>Long Loop</b>
Loop Resistance	Min 300 $\Omega$ , Max 700 $\Omega$	Min 300 $\Omega$ , Max 1800 $\Omega$
Termination Impedance	600 + 2.16 uF	
<b>VF Transmission</b>		

<b>Characteristics</b>	
Nominal Transmit TLP	Software configurable, -10.0dB to +5.0dB, steps of 0.1dB
Nominal Receive TLP	Software configurable, -10.0dB to +2.0dB, steps of 0.1dB
2-Wire Return Loss	>28 dB Echo, >20 dB singing (against 600 ohm, in series with 2.16 uF with additional 25 ohm resistor between tip and ring)
<b>PCM Coding</b>	Software configurable, A-Law, A-Law inverted, u-Law
<b>Transhybrid Loss</b>	Echo: 20dB, SRL-LO: 12dB, SRL-HI: 12 dB
<b>Standards Conformance</b>	
AT&T TR43801	Digital Channel Bank Requirements and Objectives - November 1982;
BellCore TR-NWT 000057	Functional Criteria for Digital Loop Carrier System - January 1993
BellCore GR-63-CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protection
ITU-T G.712	(11/96) - Transmission Performance Characteristics of Pulse Code Modulation (replaces G.712, G.713, G.714 and G.715)
ITU-T Q.552	<b>Transmission Characteristics of 2 -wire analog interface of a Digital Exchange</b>
FCC Part 68	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
FCC Part 15	Subpart 15
UL 1459	UL Standard for Safety, Telephone Equipment

## 2. Foreign Exchange Office (FXO) Card

The IMACS supports only one variant of Foreign Exchange Office (FXO) card:

- 813960/813970 FXO Card provides eight 2-wire analog ports with terminating impedance of 600 ohms.

FXO cards can be installed in any of the User Slots of the IMACS chassis. FXO cards encode the incoming analog voice signals into 64 Kbps PCM format before transmission onto the network. A Ringing Generator is required if one or more FXO ports in a system are programmed to operate in Manual Ringdown (MRD) mode. In addition, a physical jumper must be set on the FXO card for each port programmed for MRD operation. Each FXO card provides a single 50-pin female AMPHENOL connector (RJ27X).

All port parameters are software configurable on a port-by-port basis. The Mode setting specifies whether the port is to be used for standard Foreign Exchange Office, Foreign Exchange Software Defined Network, Dial Pulse Terminate, or Manual Ring Down (MRD). As described above, the MRD mode also requires the setting of physical jumpers. The Signal setting specifies Loop Start, Loop Start with Forward Disconnect, Ground Start, R2, and Immediate R2 operation. In “fxodn” and “dpt” modes, the user may also specify the wink duration time and wink delay from 0.1 seconds to 9.9 seconds in 0.1-second increments. The PCM Coding options supported include “μ-Law”, “A-Law” and inverted A-Law. The user may select the Trunk Conditioning mode (“busy” or “idle”) that should be applied towards the attached equipment should the WAN facility that the port is connected to fail. In addition, both the Transmit (Tx) and Receive (Rx) TLP levels can be set in increments of 0.1 dB. The Tx TLP range is from -10.0 dB to +5.0 dB. The Rx TLP range is from -10.0 dB to +2.0 dB.

The user may also specify, on a port-by-port basis, whether to use North American ANSI standard ABCD signaling (which is the default) or ITU (CCITT) ABCD signaling by turning the signaling conversion setting “on” or “off.” The trans-hybrid balance may be specified as one of eight values (known as “set1” through “set8”) as well as for a customized user-specified terminating impedance (“user”). All eight values are identical and are set for a terminating impedance of  $600\Omega \pm 2.15\mu\text{F}$  in the case of the Model 813960 FXO cards.

Software-initiated testing and diagnostics supported on FXO cards include the setting of both analog and digital loop backs towards the network and generating a Digital MilliWatt signal on a port-by-port basis. A robust set of Test functions allow the user to monitor and set the state of

the analog Tip and Ring leads of any FXO port. It also sets and monitors the state of the digitized voice signal's ABCD signaling bits in cross-connect systems, the Test functionality also includes the ability to generate test tones (300Hz, 1 kHz, 3 kHz and "quiet") and transmit those toward either the user side or the network side of the system. Table 11 reviews the FXO Card specifications.

**Table 11—FXO Specifications**

<b>Model 813960 2-wire Analog FXO Voice Card</b>	
<b>Physical Characteristics</b>	
Model 813960	8 ports
Physical Interface	1 female 50-pin Telco connector
Dimensions of Card	8 x 0.94 x 7.48 inches (HWD)
Weight of Card	1 lb or .4 k
Power Consumption of 813960 Card	3.03 W
Models 813960 Signaling Mode	Software configurable on a per port basis: Foreign Exchange Office (FXO), FXO Defined Network, Manual Ringdown and Dial Pulse Terminating (DPT)
Models 813960 Signaling Type	Loop Start, Ground Start, Loop Start Forward Disconnect, Loop Start R2, Ground Start Automatic, Loop Start E&M, MRD, DPT, R2, Immediate R2, Dial Pulse E&M, Caller ID
Termination Impedance	600 ohms
<b>VF Transmission Characteristics</b>	
Nominal Transmit TLP	Software configurable, -10.0dB to +5.0dB, steps of 0.1dB
Nominal Receive TLP	Software configurable, -10.0dB to +2.0dB, steps of 0.1dB
2-Wire Return Loss	>28 dB Echo, >20 dB singing (against 600 ohm, in series with 2.16 uF with additional 25 ohm resistor between tip and ring)
<b>PCM Coding</b>	Software configurable, A-Law, A-Law inverted, u-Law
<b>Transhybrid Loss</b>	Echo: 22dB, SRL-LO: 14dB, SRL-HI: 20 dB
<b>Standards Conformance</b>	
AT&T TR43801 Bell CoreTR-NWT-000057	Digital Channel Bank Requirements and Objectives – November Functional Criteria for Digital Loop Carrier System – January 1993
BellCore Protections GR-63 CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protection
ITU-T G.712	(11/96) – Transmission Performance Characteristics of Pulse Code Modulation (replaces G.712, G.713, G.714 and G.715)
ITU-T Q.552	Transmission Characteristics of 2 –wire analog interface of a Digital Exchange
ITU-T Q.553	Transmission Characteristics of 4 –wire analog interface of a Digital Exchange
FCC Part 68	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
FCC Part 15	Subpart B
UL 1459	Standard for Safety, Telephone Equipment

### 3. E&M Card

The IMACS supports three variants of E&M cards:

- 810860 E&M Card supports eight 2-wire E&M or Transmission Only (TO) ports
- 811760 E&M Card support eight 4-wire E&M or Transmission Only (TO) ports and 2713 Hz loop back support
- 811960 E&M Card supports eight 4-wire E&M or Transmission Only (TO) ports

The 811960 E&M card offers an extended Transmit TLP range (-17.5 to +14.5dB) to better support dedicated 4-wire modem applications. This may be required in situations when specific types of modems being connected to the ports cannot, or will not, change their output power levels. Modems can only be connected with the E&M when placed in TO mode.

E&M cards can be installed in any of the User Slots of the IMACS chassis. E&M cards encode the incoming analog voice signals into 64 Kbps PCM format before transmission onto the network. Each E&M card provides a single 50-pin female AMPHENOL connector (RJ27X). All three cards support E&M signaling types I, II, IV and V.

Most port parameters are software configurable on a port-by-port basis including the Mode of each port (“E&M”, “E&MR2” or “TO”). The PCM Coding to be used is either u-Law, A-Law or A-inv (for inverted A-Law). The Trunk Conditioning (busy or idle) is configured on the equipment in case the WAN facility that the port is connected to fails.

The user may also specify, on a port-by-port basis, whether to use North American ANSI standard default, ABCD signaling, or ITU (CCITT) ABCD signaling by turning the signaling conversion setting “on” or “off”.

Software-initiated testing and diagnostics supported on E&M cards include the setting of both analog and digital loop backs towards the network and the generation of a Digital MilliWatt signal on a port-by-port basis. A robust set of test functions allow the user to monitor and set the state of the analog E & M leads of any port and to set and monitor the state of the ABCD signaling bits of the digitized voice signal. In cross-connect systems, the Test functionality also includes the ability to generate test tones (300Hz, 1 kHz, 3 kHz and “quiet”) and transmit those toward either the user side or the network side of the system.

The 811760 E&M with 2713 Hz Loop back will provide digital loop back (both PCM voice and signaling) when activated by a 2713 Hz tone of specified level and duration. This complies with requirements as per Bellcore PUB 42004.

When a validated tone is detected the channel disconnects the transmit path from the user and provides loop back of signals (PCM voice and signaling) received from the network. The loop back is performed at “equal level”, i.e. without inserting any gain or loss in the path. In addition, a “make busy” signal is being applied towards the user. Table 12 reviews the E&M card specifications.

**Table 12—E&M Analog Voice Card Specifications**

<b>Models 810860 2-wire Models 811760 and 811960 4-wire E&amp;M Analog Voice Card</b>	
<b>Physical Characteristics</b>	
Model 810860 and 811960	8 ports
Physical Interface	1 female 50-pin Telco connector
Dimensions of Card	8 x 0.94 x 7.48 inches (HWD)
Weight of Card	1 lb or .4 k (Model 811960)
Power Consumption of Card	3.5 W (Model 811960)
Signaling Mode 2-wire (810860) 4-wire (811960)	Software configurable on a per port basis: E&M, Transmit Only, Symmetrical R2 signaling, E&MR2, Modified R2 (r2mod)
Signaling Types	Types I, II, V are switch configurable by card. Supports Normal

	(toward user) and Tandem (toward CO)
E&M Sensor Characteristics	2-wire (810860) and 4-wire (811960), Impedance > 15K ohms, Sensitivity > 2.5 mA
Nominal Transmit TLP	Software configurable, -16.5dB to +7.3dB, steps of 0.1dB (2-wire); -17.5 dB +14.5dB, steps of 0.1 dB (4-wire)
Nominal Receive TLP	Software configurable, -16.3dB to +7.5dB, steps of 0.1dB (2-wire); -16.3dB +7.5dB steps of 0.1dB
Termination Impedance	600 Ohms with 2.16 uF capacitor in series (2-wire); 600 Ohms (4-wire)
<b>Delay Specification</b>	
Absolute Group Delay (dependent on codec)	<600 us (2-wire and 4-wire)
Peak to Average Ratio (PAR)	94 to 97 (2-wire and 4-wire)
<b>Standards Conformance</b>	
AT&T TR43801	Digital Channel Bank Requirements and Objectives – November 1982
Bell Core TR-NWT-000057	Functional Criteria for Digital Loop Carrier System – January 1993
BellCore GR-63 CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protection
ITU-T G.712	(11/96) – Transmission Performance Characteristics of Pulse Code Modulation (replaces G.712, G.713, G.714 and G.715)
ITU-T Q.552	Transmission Characteristics of 2 –wire analog interface of a Digital Exchange
ITU-T Q.553	Transmission Characteristics of 4 –wire analog interface of a Digital Exchange
FCC Part 68	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
FCC Part 15	Subpart B
UL 1459	Standard for Safety, Telephone Equipment
UL 1950	UL Standard for Safety of Information Technology Equipment
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment



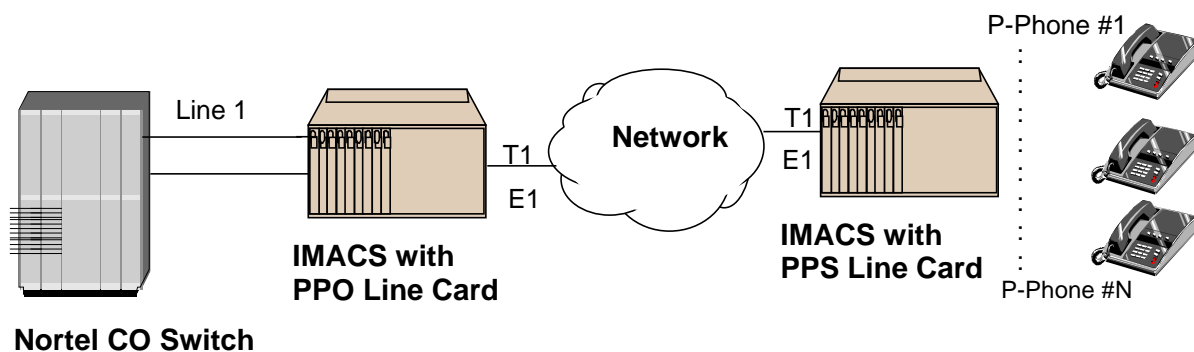
## P-Phone Station and Office Line Cards

The P-Phone Line Cards support transport of Nortel Electronic Business Service (EBS) or P-Phone service. Nortel's EBS is provided through the use of an Electronic Business Set (also EBS) capable of supporting premium Meridian Digital Centrex (MDC) features offered by the local DMS SuperNode switch. A data channel allows out-of-band signaling between the EBS and the DMS SuperNode switch. This data channel allows the user to activate MDC features, such as conference calling, by simply pushing special keys on the EBS, and for the DMS SuperNode to deliver information, such as calling number identification, to the EBS display.

P-Phone is a very popular service among large corporations who have chosen Nortel Centrex vs. a PBX. This service is very popular in metropolitan areas; as more companies move away from purchasing their own PBXs, P-Phone will be even more popular among the corporate DMS customers. In addition, as more and more CLECs enter traditional RBOC bases, they will need to be able to provide P-Phone services.

Figure 10A shows a general application drawing where an IMACS system is used at both the CO end and at the customer remote end. As shown, there are two applications of the Line Card, one at the office end, also known as P-Phone Office (PPO), and one at the station end referred to as P-Phone Station (PPS).

**Figure 10 - Universal IMACS P-Phone Application**



Two types of P-Phone line cards are used in pair gain carrier systems such as DLCs and the IMACS system. One type, referred to as a passive line card, encodes the received out-of-band signaling tones, transports them across the carrier and decodes the digital representation back to out-of-band tones at the other end. In other words, the passive line card simply repeats the signaling end-to-end. The second type, referred to as an active line card, terminates the messages received at the 2-wire port and either responds as appropriate to the local terminal device or forwards the message over the digital carrier.

The above figure shows just one working circuit. In reality, the Line Card will be able to support eight (8) working circuits. The most common application for P-Phone would have more than one circuit going to a customer location. Very rarely would there be just one circuit terminating at one customer. The P-Phone line cards support the following Nortel PBXs, switches and Meridian business phone sets:

- DMS100 (Class 5 switch)
- DMS500 (Combinations of Class 5 and a tandem switch)
- DMS10 (Lower capacity switch for rural areas)
- SL100 (Large enterprise PBX; same as DMS100)
- M5000 series business sets

Table 12A reviews the PPO and PPS line card specifications.

**Table 12A—PPO and PPS Line Card Specifications**

<b>Models 812160 and 813160 Eight Channel Line Card</b>	
<b>Physical Characteristics</b>	
Model 812160 and 813160	8 channels
Software provisionable options	Level control and A-Law/Mu law
Transport length	Over 3,000 feet of copper cable at 2W VF ports
Out of band signaling	8 kHz tone, ASK, half duplex
<b>Voice Transmission</b>	7-bit voice encoding scheme. LSB used to carry signaling.
<b>Status Indicators</b>	Loop current, presence or absence at the local end; loss of sealing current, far end
<b>Subscriber and Central Office Interface—Transmit Channel</b>	
Levels received from 2W port	-2 dBm to +1 dBm
Level adjustment	-3 to +2dB in 0.1 dB increments
Attenuation distortion (relative to 1 kHz)	-0.5 to +1.0 db, 400 Hz to 2800 Hz
Idle channel noise	≤ 23 dBmC

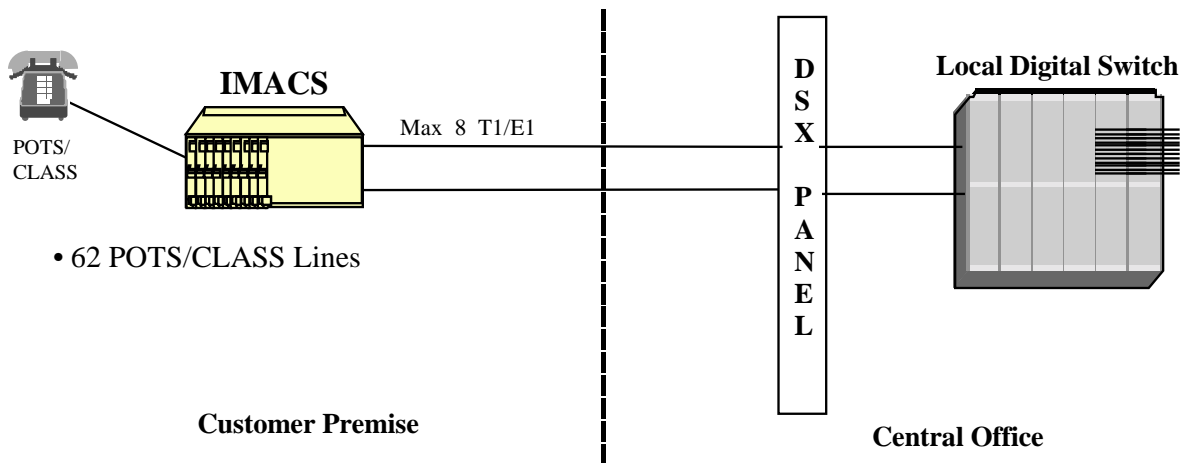
**Table 12A—PPO and PPS Line Card Specifications (continued)**

<b>Subscriber and Central Office Interface—Receive Channel</b>	
Level generated to 2W port with 0dB loss	0 dBm $\pm$ 0.5 Db
Level adjustment	-3 to +2 dB in 0.1 dB increments
Attenuation distortion (relative to 1 kHz)	-0.5 to +1.0 db, 400 Hz to 2800 Hz
Idle channel noise	$\leq$ 23 dBmC
<b>2W Port Characteristics</b>	
Maximum connected copper loop	3000 feet, 26 gauge, non-loaded pair
Impedance	900 ohms
Return Loss, voiceband into 900 $\Omega$ + 2.16 $\mu$ F	> 18 dB ERL, > 0 dB SRL LO, HI
Return loss, single frequency into 900 $\Omega$ + 2.16 $\mu$ F	> 25.6 dB @ 8 kHz
<b>Sealing Current Source</b>	
Minimum voltage at NI (display set)	15.8 V into a 38 ma sink through 3000 ft
Minimum voltage at NI (non-display set)	14.5 V into a 17 mA sink through 3000 ft
Loop length	0 to 3000 feet
Polarity	Ring lead must be negative relative to tip lead
<b>Sealing Current Sink</b>	<960 ohms DC resistance
<b>8 kHz Signaling Specifications</b>	
Signaling method	ASK half duplex, carrier only present during transmission of information or acknowledgment
Signaling rate	1 kb/s, half duplex
Received 8kHz signal levels at 2W port	.200 to 1.5 V peak to peak
<b>Standards Conformance</b>	
BellCore GR 1089-CORE, Section 2	ESD Protection
BellCore GR 1089 section 3 and EN 500 81-1, Level B	Radiated Emissions
BellCore GR 1089 CORE, Section 3	Conducted Emissions
BellCore GR 1089 CORE, Section 3	Immunity
FCC Part 68	Requirements for Connection of Terminal Equipment Systems and Protective Apparatus to the Telephone Network
FCC Part 15	Subpart B
UL 1459	Standard for Safety, Telephone Equipment
UL 1950	UL Standard for Safety of Information Technology Equipment
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment

### Voice Channel Bank Application

This is the simplest IMACS application, which can be used by a service provider. The IMACS is used in this configuration when one or more digital T1/E1 trunks are needed to interface with analog PBXs or key systems at the customer premises. In the US, the break-even point for bringing in a T1 trunk as opposed to multiple analog lines is typically 6 analog lines. As a result, there is a huge market for cost-effective voice channel bank such as the IMACS. A single IMACS can be used to provision up to 62 analog POTS lines (FXS, FXO, E&M) on digital Central Office switches as shown in Figure 11.

**Figure 11—IMACS As A Voice Channel Bank**



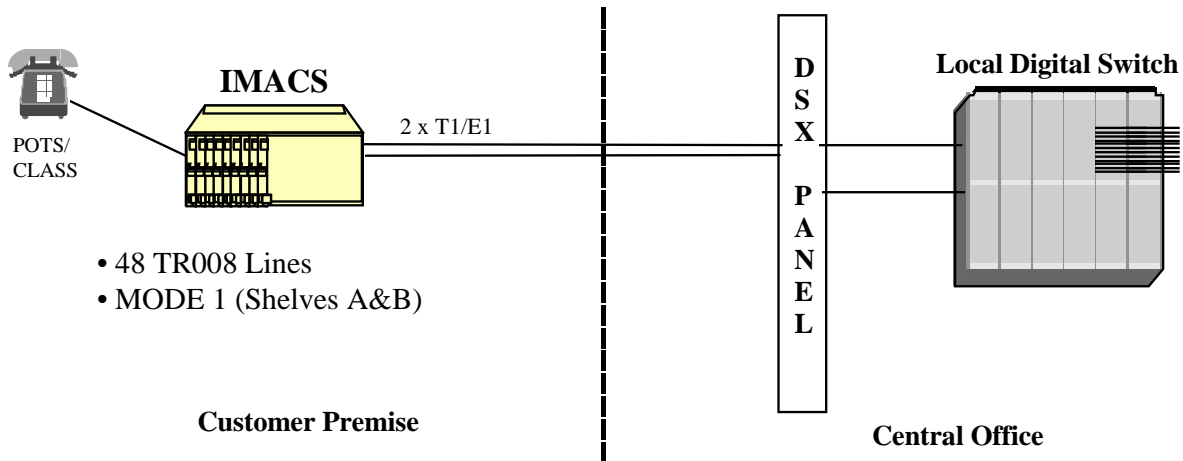
The IMACS can also be deployed in applications, which do just the reverse of voice channel banks. This is most likely to be found in wireless local loop applications in which the wireless service provider may use a state-of-the-art wireless local loop. The output of the wireless base station is normally a T1/E1. However, the existing PSTN may still have analog switches. The IMACS is used to convert from robbed-bit signaling/CAS to analog trunks (FXO).

The voice channel bank platform can be upgraded to provide an array of additional services just by adding application modules to the chassis. It comes with a built-in suite of testing and diagnostics tools, which significantly enhance the service and support capabilities.

### TR-008 Application

BellCore's TR-008 standard describes the requirements necessary for a Local Digital Switch (LDS) to connect to a remote terminal (RT) across a T1 (1.544Mbps) digital interface. The standard allows supporting from one to four T1s per RT without facility Automatic Protection Switching (APS), and two to five T1s with facility APS.

The LDS can interface the RT in Mode I (no concentration), Mode II (2:1 concentration), and Mode III (24 special-service circuits on 24 DS1 time-slots). TR-008 supports traditional POTS, CLASS, and Coin services but does not support ISDN BRI. If the service provider deploys a channel bank at the customer premise that does not provide TR-008 capability then it needs a 1/0 DCS with TR-008 capability at the central office to integrate with the LDS. The IMACS also supports TR-008 switch integration. The IMACS with TR-008 operation can connect directly to the LDS, eliminating the need for the 1/0 DCS as shown in Figure 12a.

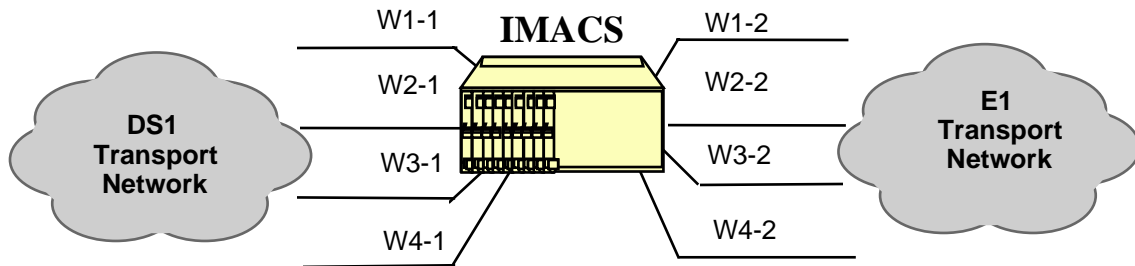


**Figure 12a - IMACS Using TR-008**

IMACS TR-008 feature can support 48 lines on 2 T1 links. IMACS is an ideal vehicle to provide integrated POTS services for line sizes of 48 and under. IMACS supports Mode I, Shelf A&B of TR-008 specification. The IMACS supports extensive testing and diagnostics capabilities, which minimizes troubleshooting and allows for high service levels.

**T1-E1 Conversion**

The Digital Access and Cross-connect System (DACS) capabilities and the signaling and companding conversion features of the IMACS can be used to provide gateway functionality between a DS1 transport network and an E1 transport network. See Figure 12b for an illustration of this capability.



**Figure 12b - IMACS Using T1/E1 Conversion**

Depending on the application, the signaling conversion can be set by the user to ITU-to-ANSI; ANSI-to-ITU or None. Similarly, the companding can be set by the user to A-Law-to-μ-Law, μ-Law-to-A-Law or none. As shown in the figure above, each WAN card must be configured with one port for DSX1 and one for CEPT. A cross-connection circuit must be made for each DS1 to E1 DSO re-assignment. Time Slots 0 and 16 cannot be used on the E1 link. Time slot 0 is used for timing and time slot 16 is used for Channel Associated Signaling (CAS). TS16 is available in data-only applications.

## IMACS Data Modules and Applications

The IMACS supports multiple user cards for transport of digital data. A list of all cards/model types that can be used in the chassis is provided in Table 13.

**Table 13—Data Card Types**

Type of Card	Description
820260 HSU Card	Supports two RS530/V.35 or RS-449 data ports via DB25 female connectors. It can also support RS232 data through the use of the appropriate Personality module. Supports 56K, 64K and Nx56/64K data applications.
820360 HSU Card	Supports two V.11/X.21 data ports which connects to RS530 or X.21 CPE devices via DB25 female connectors. The ports may be configured as user ports, or can be used as externally clocked network interface ports. Supports 56K, 64K and Nx56/64K data applications.
821260 HSU Card	Supports two V.35 synchronous data ports via two DB25 female connectors. Supports 56K, 64K and Nx56/64K data applications.
821360 HSU Card	Provides two miniature DB26 female connectors. Each port can be configured to support RS530 or V.35 devices. Interface selection is made on a port-by-port basis. The 8213 supports V.25bis dialing commands (an in-band dialing protocol) and RS-366 dialing through the use of separate DB15 pin RS-366 port connectors on the rear of the card. Supports 56K, 64K and Nx56/64K data applications.
821460 HSU Card	Supports two V.35 synchronous data ports via two DB25 female connectors. The ports can be configured as user ports, or be used as externally clocked network interface ports. Supports 56K, 64K and Nx56/64K data applications.
821560 HSU Card	Provides four miniature DB26 female connectors. Each port can be configured to support RS530 or V.35 devices. Interface selection is made on a port-by-port basis. Supports 56K, 64K and Nx56/64K data applications. Can also support RS232 data at 56Kbps through the use of the 1253xx Personality Module and 1240 cable layer. The 821570 HSU card has improved clock jitter performance.
821660 HSU Card	Provides four miniature DB26 female connectors. Each port can be configured to support RS530 or V.35 devices. Interface selection is made on a port-by-port basis. Supports 56K, 64K and Nx56/64K data applications. Can also support RS232 data at 56Kbps through the use of the 1253xx Personality Module and 1240 cable layer. Supports tail circuits greater than 24 timeslots. V.35 interface compatible with international standards, and individually selectable transmit/receive clock inversion options.

**Table 13—Data Card Types (continued)**

822060 SRU Card	Provides 10 port RS-232C/V.24 interfaces. Supports synchronous and/or asynchronous data ports from 300 bps to 38.4 Kbps.. Supports DS0-A, DS0-B, V.14 and X.50 Division 3 sub-rate multiplexing format. SRU card ports can also be multiplexed with voice traffic on an ADPCM engine (up to 19.2 Kbps data circuit in 24 Kbps ADPCM channel). The 822061 SRU card provides equivalent functionality as the 822060 except the Idle Pattern has been changed.
822160 SRU Card	Functionality equivalent to 822060 SRU card. When used with 822060, increases the SRU port density per IMACS system beyond the current limit of 60.
822460 SRU Card	The 822460 SRU has 4 DB-26 female connectors. Supports synchronous and/or asynchronous data ports from 300 bps to 38.4 Kbps. Supports DS0-A, DS0-B, V.14 and X.50 Division 3 sub-rate multiplexing formats. SRU card ports can also be multiplexed with voice traffic on an ADPCM engine (up to 19.2 Kbps data circuit in 24 Kbps ADPCM channel).
822560 SRU Card	Supports 10 RS-232E synchronous and/or asynchronous data ports from 300 bps to 38.4 Kbps. Supports DS0-A, DS0-B, V.14 and X.50 Division 3 sub-rate multiplexing formats by hardware instead of software. The configuration is controlled via local terminal or remote NMS. The SRU offers lower delay and increasing throughput. SRU card ports can also be multiplexed with voice traffic on an ADPCM engine (up to 19.2 Kbps data circuit in 24 Kbps ADPCM channel). Supports CSU, DSU and OCU loop backs.
822860 BnR Concentrator Card	Provides concentration for time slots containing diagnostics from remote IMACS units. Multiplexes up to 8 ports of Bit-7-Redundant (B7R) or B4R formatted data channels from up to 8 different DS0s onto a single, asynchronous channel at up to 38.4 Kbps. Data on the aggregate channel is in SLIP format and the interface is RS-232.
823160 FRAD Card	Frame Relay Assembler/Disassembler provides encapsulation for HDLC/SDLC or Async ports up to 38.4 Kbps. Transparent/Sync up to 38.4 Kbps. This card concentrate up to 8 non-frame inputs into 2 data streams at 56Kbps or 64Kbps. Total of 10 ports may be assigned to input (FRAD) or output (concentrator) ports based on configuration guidelines. Access to this card is via on-card RS-232 or through DS0-B over T1.
824160 and 822460 OCU-DP Cards  BRI Card	The 824160 (5 port) and 822460 (10 port) allows provisioning of DDS services or consolidation of DSU traffic as DS0-A or DS0-B. Interfaces directly to DSU at speeds up to and including 64 Kbps. Does not support BCH error correction, performance monitoring or operation in CSU mode (used only for back-to-back OCU-DP ports). Emulates an 8247 for existing system compatibility. Each port may be connected to a DSU/CSU operating at 64, 56, Switched 56, 19.2, 9.6, 4.8 or 2.4 Kbps. DSUs can be local to several thousand feet distant to IMACS based on speed and wire gauge.
OCU-DP Card 8249	The 8249 is a 2 port OCU-DP card that provides interfaces for provisioning of DDS services or consolidation of DSU traffic. Supports DS0-A or DS0-B sub-rate, 56K, 64K and Switched 56Kbps DDS. Supports BCH error correction, performance monitoring or operation in CSU mode. Secondary channel operation can be enabled if desired. Optional error correction for inter-IMACS circuits.

825460 DSO-DP Card	Provides 4 ports of DS0-DP or G.703 64K. For G.703, clock can be selected to be co- directional or contra-directional.
826070 BRI Card	This BRI-U card provides 8 ports of 2-wire 2B1Q interface via a single RJ27X (F), 50-pin amphenol connector. Adheres to 2B+D format. Supports external timing. Can be used to support NTUs for dedicated operation or for connections to BRI-U interface devices. Commonly used for BRI Terminal extension.
826170 BRI Card	This BRI-U card provides 8 ports of 2-wire 2B1Q interface via a single RJ27X (F), 50-pin amphenol connector. Adheres to 2B+D format. Supports external timing. Can be used to support NTUs for dedicated operation or for connections to BRI-U interface devices. Commonly used for BRI Terminal extension. Provides sealing (or wetting) current, 7.5mA or 15mA.
826171 BRI Card	This BRI-U card provides 8 ports of 2-wire 2B1Q interface via a single RJ27X (F), 50-pin amphenol connector. Adheres to 2B+D format. Supports external timing. Can be used to support NTUs for dedicated operation or for connections to BRI-U interface devices. Commonly used for BRI Terminal extension. Provides sealing (or wetting) current, 7.5mA or 15mA. No "DC signature" feature support.
826270 BRI Card	This BRI-S/T card provides 8 ports of 4-wire interfaces via a single RJ27X (F), 50-pin amphenol connector. Adheres to 2B+D format. Supports external timing. Provides TE, NT1 and NT2 emulation. Commonly used to provide remote extension of four wire BRI CPE devices from an ISDN PBX. Requires external power connection (-48V DC) if more than 3 cards installed in IMACS chassis unless 891330 and 8908 are used (special cable required).
826361 BRI Card	Supports 8 ports of 2-wire 2B1Q via a single RJ27X connector. Supports LULT and LUNT. Supports Bi-directional B1, B2 and D channel. Network clock for bit timing to LULT and EOC as per TR000397 using 3 DS0 TDM methods. Support Interim Performance Monitoring as per TR-000397 and TR-000829. Provides sealing current. No "DC Signature".
826461 BRI Card	Supports 8 ports of 2-wire 2B1Q via a single RJ27X connector. Supports LULT and LUNT. Supports Bi-directional B1, B2 and D channel. Network clock for bit timing to LULT and EOC as per TR000397 using 3 DS0 TDM methods. Support Interim Performance Monitoring as per TR-000397 and TR-000829. Provides "DC Signature" but no sealing current.
826462 BRI Card	Supports 8 ports of 2-wire 2B1Q via a single RJ27X connector. Supports LU, LT, LULT and LUNT and network management of NTUs (2560 and 2561). Supports Bi-directional B1, B2 and D channel. Network clock for bit timing to LULT and EOC as per TR000397 using 3 DS0 TDM methods. Support Interim Performance Monitoring as per TR-000397 and TR-000829.
828060 PM-IOR Card	Inter Office Router card is based on Lucent Technologies PortMaster product line. Connects 10BaseT Ethernet LAN to T1/E1 WAN. Uses PPP or Frame Relay and IP (TCP/IP and IPX) to route up to 1.2 Mbps through WAN. Can assign Nx56/64 Kbps DS0s. Configure router through RJ-45 console port. Supports SNMP network management.



## HSU Card

The HSU card allows the connection of high-speed data terminal equipment (DTE) and data communications equipment (DCE) to WAN links, server cards (FRS) or another HSU card. The HSU card also provides low or mid-density connectivity for local, synchronous peripherals such as, LAN Bridge/Routers and legacy SNA/SDLC devices. Additionally, these high-speed data cards provide broadcast functionality for point to multi-point operations suitable for applications such as video-conferencing. When used in conjunction with an 8840 PRI Server Card, the HSU card can be used to provide switched data application functionality. All HSU cards can be installed in any of the User Slots in an IMACS chassis.

Each port on a HSU can be independently configured to operate at speeds of Nx56 or Nx64 Kbps, where N equals 1 to 24 in T1 mode or 1 to 31 in E1 mode. In addition to the data rate, each synchronous port's Transmit Clock can be programmed for Internal or External modes and both the Clock and Data Polarity may be inverted through software. The External Transmit Clock mode and the Inverted Clock Polarity mode may be useful in ensuring that both the Transmit Clock and the Transmit Data are in sync when they reach the HSU port. This should occur when the HSU port and the attached device are connected over a long cable. The Data Polarity may be inverted to ensure the density for Nx64 Kbps data circuits supporting HDLC-based protocols that are connected to non-B8ZS T1 facilities.

The "Clear To Send" control lead may always be set to high, low or local mode. In local mode, the CTS signal reflects the state of the Request To Send (RTS) signal that is received from the attached DTE device. In that mode, the delay between RTS and CTS is software set-able, with options of 0, 30, 60 or 100 milliseconds. Additionally, if the HSU port is programmed to operate at Nx56 Kbps, then RTS will be transmitted end-to-end and presented as RLSD at the far end of the circuit.

Software-initiated diagnostics support the setting of local loop backs towards either the network or the attached DTE equipment. Additionally, a remote loop back function allows the HSU card to generate three DDS-compatible latching loop back codes for the far-end OCU, CSU and DSU equipment. Similarly, the HSU data port may be programmed to detect and respond to both latching and non-latching DDS-format OCU, CSU and DSU loop back codes initiated from the remote end of the circuit. A time-out option authorizes the HSU port to automatically release the loop back after ten minutes. This feature applies to an HSU port that is running at 56 Kbps or for super-rate circuits if the loop back code is transmitted in the first super-rate's DSO. The card can also generate and recognize two industry standard in-band loop-up and loop-down codes that act on the entire super-rate circuit. Those are the ITU (CCITT) V.54 code and the ANSI Fractional T1 code.

Additionally, the integral Bit Error Rate Tester (BERT) can be used to generate test patterns and route those towards the WAN facility. These test patterns can then be used to verify synchronization and measure circuit quality. For further information regarding Performance Monitoring and Diagnostic Capabilities, see Section 13, IMACS System Testing and Diagnostics.

## Applications

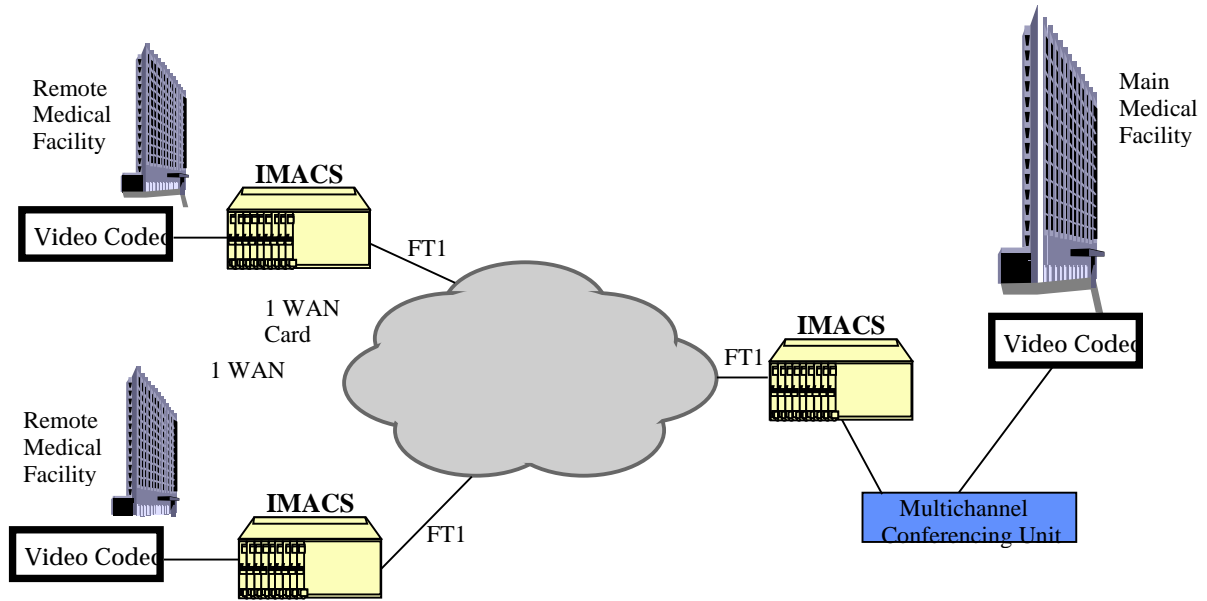
There are several business applications the IMACS equipped with an HSU card supports.

- LAN to LAN
- LAN to WAN to LAN
- Work Station to Computer
- Computer to Computer
- Compressed Video
- CAD/CAM
- Call Center

## IMACS and HSU Application Example

A major Health Maintenance Organization has numerous locations, which have a Central main hospital facility and smaller satellite facilities. The HMO cannot afford to fully staff each main and satellite site with specialists. As patients enter the satellite facilities, video and audio sessions can be established with the specialists at the Main

hospital. Although the satellite sites are not equipped with Intensive Care Units, emergencies can be admitted and support solicited from the Main hospital personnel as shown in Figure 13.



**Figure 13 - Point to MultiPoint One-Way Video and Audio Using HSUs**

Table 14 describes the various high-speed data cards.

**Table 14—820260, 820360, 821260, 821360, 821460, 821560, 821570 and 821660 High-speed Data Cards**

Model Number	Number of Data Ports	Physical Interfaces	Electrical Interfaces
Model 820260	2	2 female 25-pin DB25 D-connectors	ITU-T V.35, RS232, RS530/RS449
Model 820360	2	DB25 female connectors	ITU-T V.11, RS 530
Model 821260	2	2 female 25-pin DB25 D-connectors	ITU-T V.35 (True V.35)
Model 821360	2	2 female 26-pin DB26 D-connectors 2 DB15 female connectors	ITU-T V.35, V.25bis, RS366, RS530 (V25 bis and/or RS-366 dialing when used with 8840 PRI Card)
Model 821460	2	2 female 25-pin DB26 D-connectors	ITU -T V.35 (True V.35),
Model 821560 Model 821570 (improved clock jitter performance)	4	4 female 26-pin DB26 D-connectors	RS530, RS-232, V.35 devices
Model 821660	4 female DB26 connectors RS530, RS-232 and True V.35 devices		
	Nx56K and Nx64K where N=1 to 31 (up to 1984 Kbps)-Software Configurable by port		
Data Format	Synchronous		
Data Protocol	Transparent		
Transmit Clock per Port	Internal or external (software configurable)		
Clock Polarity per Port	Normal or inverted (software configurable)		
Data Polarity per Port	Normal or inverted (software configurable)		
<b>Dial Capability</b>	Model 8213 only when used with 8840 PRI Server Card		
Number of Dialing Ports	2		
Dialing Electrical Interface	EIA RS-366, ITU-T V.25 bis		
Dialing Physical Interface	2 female 15-pin D-connectors		
<b>Performance Statistics</b>	Errored Seconds, Unavailable Second, Severely Errored Second, Burst Errored Second, Loss of Packet Seconds, Loss of Frame Count		
<b>Standards Conformance</b>			
ITU-T V.35	Data Transmission of 48 kbps Using 60-108 kHz Group Band Circuits		
ITU-T V.11 (10/96)	Electrical characteristics for balanced double-current interchange circuits operating at data signaling rates up to 10 Mbps		
ITU-T v.24	(10/96) - List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)		
ITU-T V.28	Electrical characteristics for unbalanced double-current interchange circuits		
ITU-T G.704 (7/95)	Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44 736 Kbps hierarchical levels		
ITU-T V.25bis	(Model 8213 only) (10/96) - Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically		
EIA RS-422	Electrical characteristics of balanced voltage digital interface circuits		
EIA RS-449	General purpose 37 position and 9 position interface for DTE and DCE equipment employing serial binary data interchanges		

EIA RS-530	High-speed 25 Position Interface for Data Terminal Equipment, Including Alternative 25 Position Connector.
EIA RS-366	Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication
FCC Part 15	Subpart B
UL 1950	UL Standard for Safety of Information Technology Equipment
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment
BellCore GR-63-CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protection

## 2. SRU Card

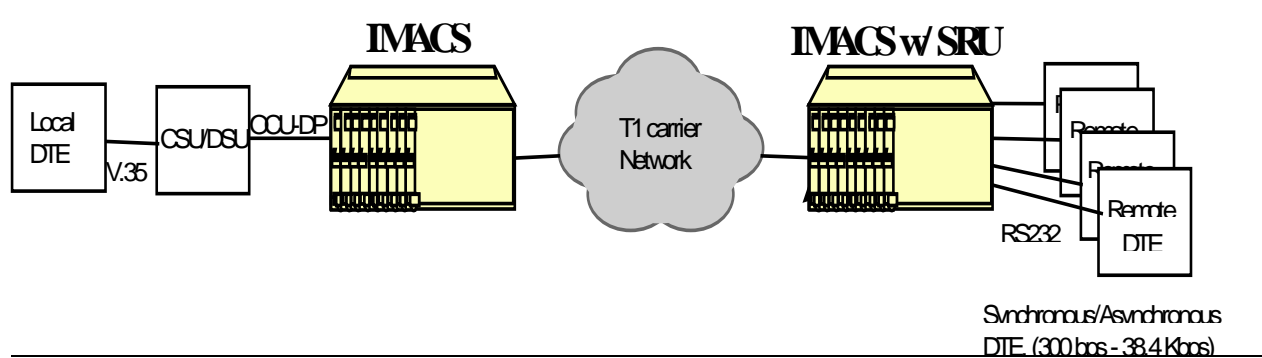
The 822060/822161 SRU Card allows synchronous or asynchronous connections of up to ten RS-232, low-speed and medium-speed (300 bps to 38.4 kbps) data terminals to the integrated access system. Since an SRU port does not require a complete 64Kbps time slot, the Sub-Rate card allows the multiplexing of a number of devices into a single, subdivided time slot on a WAN card. SRU card ports can also be multiplexed with voice traffic on an ADPCM engine. The 822060 accesses user buses A & B, and the 822161 SRU accesses user buses C & D. The 822061 SRU has equivalent functions as the 822060 with the exception of Idle Pattern changes. The 822460 SRU has 4 RS-422 ports that support synchronous and/or asynchronous connections from 300 bps to 38.4 Kbps. The Low Delay SRU provides 10 RS-232E ports that support synchronous and/or asynchronous V.14 operations. The sub-rate multiplexing is performed by hardware instead of software.

Each RS-232 port can be independently programmed for synchronous (including HDLC) or asynchronous operation. Synchronous operation is available at speeds of 2.4 Kbps up to 38.4 Kbps while for asynchronous the range is 300 bps up to 38.4 Kbps. Each synchronous port can receive timing from either the DTE device or the system clock. If the DTE supplies the transmit clocking, it must be synchronized with the system clocking source. For each asynchronous data port, the stop bits, data bits and parity are user configurable. The SRU incorporates a built-in V.14 Async-to-sync converter to avoid over-sampling and consequently saves bandwidth. Asynchronous data circuits are converted to synchronous mode by the SRU card prior to multiplexing onto a WAN aggregate.

Sub-rate data ports are multiplexed into industry standard DSO formats. The user may specify the format of the DSO that the data port is assigned to. The choices are: DSO-A which allows only one data port to be mapped into the DSO and DSO-B which allows multiple data ports from multiple SRU cards in the system to be mapped into the same DSO time slot. If the DSO-B format is selected, then the user can specify the type of DSO-B format required (b-5, b-10 and b-20) and the sub-rate position that the data port will occupy within the DSO-B frame.

In b-5 mode, the DSO is divided into five sub-rate positions, each of which are occupied by a data port operating at 9.6 Kbps, 4.8 Kbps, or 2.4 Kbps. Additionally, one or two 19.2 Kbps circuits are supported in b-5 mode. Each would occupy two of the five sub-rate positions. Additionally, data circuits running at 28.8 Kbps or 38.4 Kbps are supported in b-5 mode and will occupy three or four of the five available sub-rate positions. In b-10 mode, the DSO is divided into ten sub-rate positions, each of which are occupied by a data port operation at 4.8 Kbps or 2.4 Kbps. In b-20 mode, the DSO is divided into 20 sub-rate positions, each of which are occupied by a data port operating at 2.4 Kbps.

In the application shown in Figure 14, the IMACS with the SRU card (on the right hand side) can either send each sub-rate on a separate DSO (DSO-A format) or groom multiple sub-rate channels into a single DSO (one of the DSO-B formats).



**Figure 14 - IMACS With SRU Card Application**

The SRU card also supports X.50 division 3, an ITU (CCITT) standard for sub-rate multiplexing. The maximum bandwidth of the SRU card is 115.2Kbps. The SRU card provides the ability for software configurable delay optimization. If delay optimization is used on all 10 ports, the maximum bandwidth available will be 76.8Kbps. Software-initiated diagnostics supported on the SRU card is the same as on the HSU card. Table 15 describes the SRU card specifications.

**Table 15—SRU Card Specifications**

Model Number	# of data ports	Physical Interfaces	Electrical Interfaces
<b>822060 SRU Card</b>	<b>10</b>	<b>10 female 8-pin RJ-48</b>	<b>RS-232C, V.24</b>
<b>822061 SRU Card</b>	<b>10</b>	<b>10 female 8-pin RJ-48</b>	<b>RS-232C, V.24</b>
<b>822160 SRU Card</b>	<b>10</b>	<b>10 female 8-pin RJ-48</b>	<b>RS-232C, V.24</b>
<b>822460 SRU Card</b>	<b>4</b>	<b>4 female 26 pin DB-26</b>	<b>RS-422</b>
<b>822560 SRU Card</b>	<b>10</b>	<b>10 female 8-pin RJ-48</b>	<b>RS-232E</b>
Operational Interface	DCE—full duplex		
Interface Settings	Asynchronous, synchronous, V.14		
Sub-rate Framing Format	X.50, V.14, DSO-A, DSO-B with 5, 10 or 20 divisions per DSO		
Sub-rate Time slot number	1 through 20 depending on sub-rate framing format		
<b>Synchronous Data</b>			
Format	Transparent		
Transmit Clocking	Software configurable per port; internal or external		
Speeds	2.4; 4.8; 9.6; 14.4; 19.2; 28.8 and 38.4 Kbps		
<b>Asynchronous Data</b>			
Format	V.14 or proprietary		
Stop Bits	Software configurable per port; 1 or 2		
Data Bits	Software configurable per port; 5, 6, 7 or 8		
Parity	Software configurable per port; none, odd, even, space or mark		
Speeds	2.4; 4.8; 9.6; 14.4; 19.2; 28.8 and 38.4 Kbps		
<b>Signaling</b>			
DSR	Tied to DTR		
CTS	Software configurable per port; on, off (tied to RTS)		
CTS delay	Software configurable per port; immediate, 30, 60 or 100 ms		
RLSD	Software configurable per port; permanently on, follows remote RTS (drop on receipt of IDL or CGA RED)		
<b>Standards Compatibility</b>			
	Network Equipment-Building System (NEBS) Requirements: Physical Protection		
AT&T TR54075	Sub-rate Data Multiplexing - A Service of DATAPHONE Digital Service		
ITU-T V.24	Definitions for Interchange Circuits Between DTE and CE		
ITU-T V.28	Electrical characteristics for unbalanced double-current interchange		
ITU-T X.50 Division 3	Fundamental Parameters of a Multiplexing Scheme for the International Interface Between Synchronous Data Networks (note: does not support 600bps data)		
ITU-T V.14	Transmission of Start-Stop Characters over Synchronous Bearer Channels (using Async to synch converters)		
EIA RS232	Interface between DTE and DCE employing serial binary data interchange		
FCC Part 15	Subpart B		
UL 1950	UL Standard for Safety of Information Technology Equipment		
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry		
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry		
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment		

### 3. FRAD Card

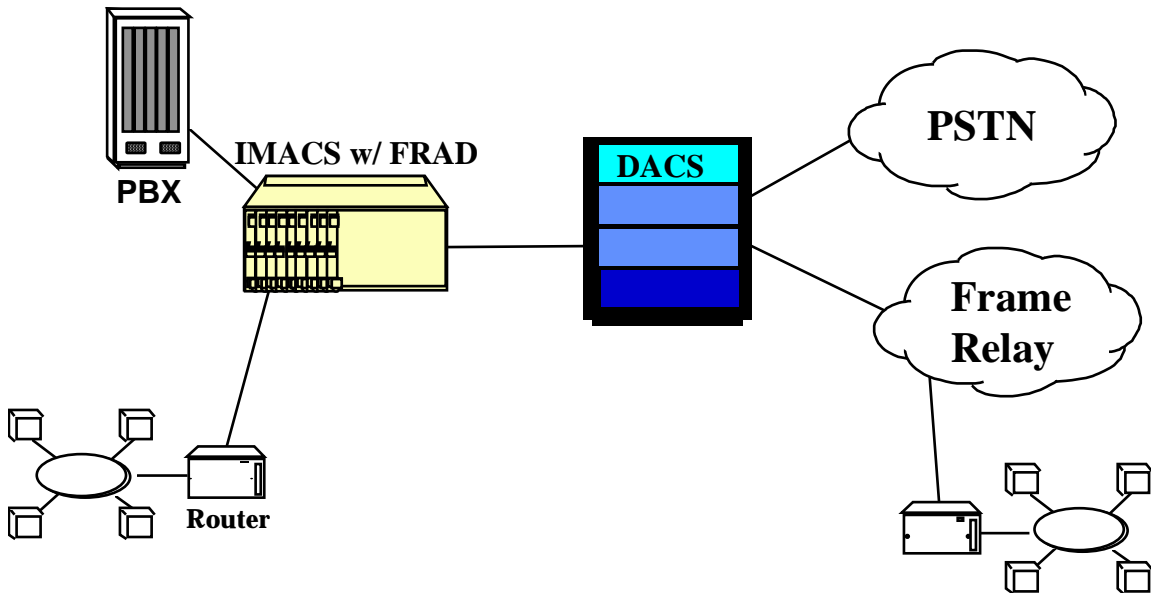
The 823160 Frame Relay Assembler/Disassembler (FRAD) user card provides eight ports for transport of low speed data across Frame Relay Networks. The FRAD can encapsulate HDLC protocols (such as SDLC). Each port can be independently configured for asynchronous, transparent synchronous data or HDLC.

When taking data from the on-board RS-232 port, the FRAD card supports speeds of 2.4, 4.8, 9.6, 14.4, 19.2, 28.8 and 38.4 Kbps, independently configured on a per port basis. The aggregate Frame Relay encapsulated traffic coming out of the WAN card can be configured to transmit at 56Kbps or 64 Kbps.

When processing HDLC data, the flags and the CRC are removed before assembling the frames. For asynchronous data, start and stop bits are removed before the frames are assembled. Other data is treated as a transparent data stream and all bits will be encapsulated into transmitted frames. The FRAD card supports proprietary sub-addressing over a PVC. This sub-addressing is transparent to the Frame Relay Transport Network, and allows multiple ports on a single FRAD to share the same PVC, resulting in lower costs.

The FRAD card also maintains performance statistics detailing the number of frames transmitted, number of frames received, number of octets transmitted, number of octets received, number of frames dropped before being received during a 15 minute interval and a status field describing the conditional that caused the dropped packets (DTE port down, loop back in progress or port in standby). All these performance statistics are gather for 24 hours, in 1-hour intervals. The FRAD card also provides test frame generators for additional diagnostics.

In the application represented by the Figure 16 , the router on the left (at a remote office) is connected to the IMACS via the FRAD card at 9.6Kbps, along with other voice traffic from a PBX. The router traffic is mapped onto a DS0 on the T1 link to the Central Office where it is separated by a DACS and directed towards a Frame Relay network and switched/routed to the destination router at the headquarters. See Figure 15 for an illustration of the FRAD Card's capabilities and Table 16 for the FRAD Card's specifications.



**Figure 15 - IMACS FRAD Card Application**



**Table 16—FRAD Card Specifications**

<b>Model 823160 FRAD Card</b>	
Number of Ports	10
Speeds	2.4; 4.8; 9.6; 14.4; 19.2; 28.8 and 38.4 Kbps
Physical Interface	10 Female 8-pin RJ-48
Electrical Interface	RS232, ITU-T V.28
Data Format	Synchronous and asynchronous
Data Protocol	Async or HDLC (SDLC); transparent
DLCI	16 to 991
LMI	ANSI, CCITT, LMI (Gang of Four)
Maximum Frame Size	5 to 512 bytes
Frame Relay Aggregate Rate	56 or 64 kbps
Time Slot Number for WAN	1 through 31 on an WAN (T1/E1) link
<b>Diagnostics</b>	
HDLC Test Pattern	Active or inactive
Loop Back	To DTE, to network or remote
<b>Synchronous Data</b>	
Format	Transparent
Transmit Clocking	Software configurable per port; internal or external
<b>Asynchronous Data</b>	
Format	V.14 or proprietary
Stop Bits	Software configurable per port; 1 or 2
Data Bits	Software configurable per port; 5, 6, 7 or 8
Parity	Software configurable per port; none, odd, even, space or mark
Speeds	2.4; 4.8; 9.6; 14.4; 19.2; 28.8 and 38.4 Kbps
<b>Standards Compatibility</b>	
BellCore GR-63-CORE	Network Equipment-Building System (NEBS) Requirements: Physical Protection
AT&T TR54075	Sub-rate Data Multiplexing - A Service of DATAPHONE Digital Service
FCC Part 15	Subpart B
ITU-T V.28	Electrical characteristics for unbalanced double current interchange currents
UL 1950	UL Standard for Safety of Information Technology Equipment
CE EN 500 81-1	Electromagnetic compatibility generic emission standard Part 1 Residential, commercial and light industry
CE EN 500 82-1	Electromagnetic compatibility generic immunity standard Part 1 Residential, commercial and light industry
CE EN 60 950/A2	Safety of information technology equipment including electrical business equipment

## 4. OCU-DP Card

The OCU-DP (Office Channel Unit - Data Port) is used to interface directly to DSU/CSUs (Data Service Units Channels Service Units) supporting data traffic up to and including 64Kbps. A four-wire circuit can connect the OCU-DP card to a DSU/CSU that can be located up to four miles away. In switched 56 Kbps mode, users can access the network on an as-needed basis by dial-up commands. The system unit must be equipped to provide -48 VDC power to fully support the functionality of the OCU-DP card.

### OCU-DP Card Models

The IMACS supports three cards for support of external CSU/DSUs:

- 8249 OCU-DP 2 Port Card
- 824160 OCU-DP 5 Port Card
- 824660 OCU-DP 10 Port Card

The 8249 OCU-DP card supports two ports while the 824160 and 824660 are five and ten port cards, respectively. All OCU-DP cards support RJ48 female connectors.

Each OCU-DP port can be independently programmed to operate at 2.4, 4.8, 9.6, 19.2, 56 and 64 Kbps in either DSO-A, (one channel per DS0) or DS0-B format, which allows multiple data ports from multiple OCU-DP cards in the system to be mapped into the same DS0 time slot. If the DS0-B format is selected, the user then specifies the type of DS0-B format required (b-5, b-10 or b-20) and the sub-rate position that the data port occupied by the data port within the DS0-B frame.

In switched-56K mode, an OCU-DP port provides a connection for an external Switched-56K DSU/CSU that will perform all call set-up and dialing functions. The OCU-DP card converts the call set-up commands into standard signaling and sends the signaling over the WAN facility.

All OCU-DP cards support a low speed secondary channel that is established in the 8<sup>th</sup> bit position of the DS0 time slot to which the OCU-DP port is assigned. The secondary channel can be used for testing and maintenance of the main circuit or for the transmission of other, independent, low speed data. The specification table shows the secondary channel rates associated with the standard primary port rates of the OCU-DP card.

The 8249 OCU-DP card also supports two methods of error correction. The first is known as "Majority Vote" and applies to the lower data rates, specifically, 2.4, 4.8 and 9.6 Kbps. The other is known as the BCH (Bose-Chaudhuri-Hocquenghem) method and applies to data rates of 19.2 Kbps and 56 Kbps. In the case of a 19.2 Kbps circuit, the error correction information is placed in the same DS0 that the circuit occupies. In the case of a 56 Kbps circuit, the error correction information is placed in a following, adjacent DS0 time slot on the WAN aggregate.

On all OCU-DP cards, performance statistics are collected by the system and are available through the user interface. Performance statistics include Errored Seconds (any second with an error), Severely Errored Seconds (any second with an error rate exceeding 10E-3) and Consecutive Severely Errored Seconds (CSES). They are displayed in one-hour intervals for up to 24 hours. CSES are counted by the system once ten consecutive Severely Errored Seconds are logged. The counter stops when the system logs ten consecutive non-Severely Errored Seconds. An OCU-DP port on the 8249 card may be programmed for OCU mode or CSU mode. OCU mode is the most common and is used whenever the OCU-DP port attaches to a CSU/DSU over a four-wire circuit. CSU mode allows the card to be connected directly to the digital network.

Software initiated diagnostics supported by the OCU-DP card include the setting of six different loop backs. Three of these act on the OCU-DP card itself and are known as local loop backs and the other three generate loop back patterns to remote devices and are known as remote loop backs. Among local loop backs, there are three types:

- Loop backs of the 4-wire analog interface of the OCU-DP port towards the attached CSU
- Loop backs of the 4-wire OCU-DP interface towards the network
- Loop backs towards the network at the point where the OCU-DP card interfaces with the system bus

All three remote loop backs are latching loop backs. These latching loop backs are:

- Loop back of the analog interface of the remote OCU-DP device back towards the network
- Loop back of the 4-wire interface of the remote CSU device back towards the network
- Loop backs of the 4-wire interface of the local CSU device towards the network.

An OCU-DP port may be programmed to detect and respond to both latching and non-latching (i.e., alternating) DDS-format OCU loop back codes that are initiated from the remote end of the circuit. A time-out option authorizes the OCU-DP port to automatically release the loop back after ten minutes.

Table 17 depicts the OCU-DP card's specifications. For further information regarding Performance Monitoring and Diagnostic Capabilities, see Chapter 13, IMACS System Testing and Diagnostics.

**Table 17—OCU-DP Specifications**

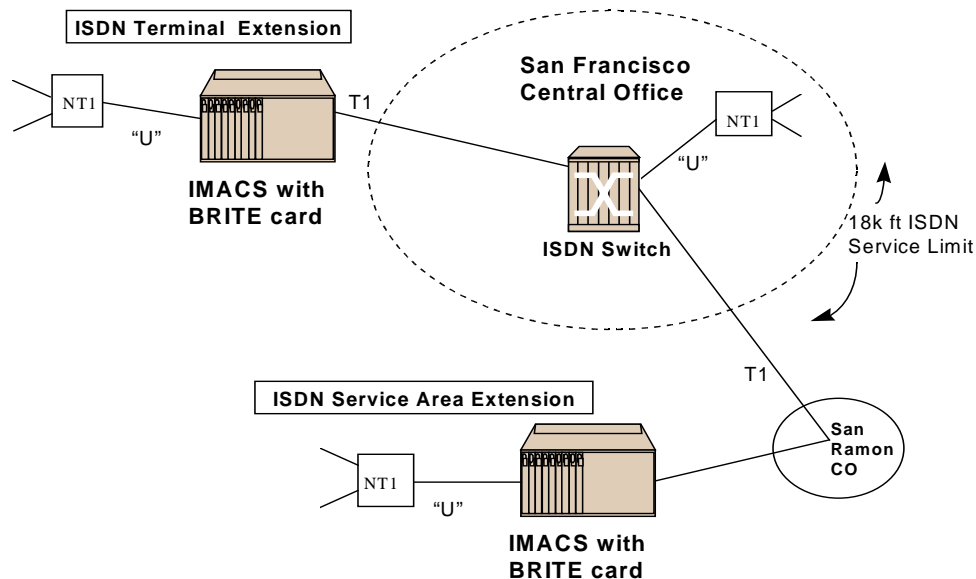
Model Number	Number of Ports	Physical Interfaces					
Model 8249	2	Female 8-pin RJ-48					
Model 824160	5	Female 8-pin RJ-48					
Model 824660	10	Female 8-pin RJ-48					
Data Format	Synchronous—binary, serial						
Data Encoding	Bipolar, return to 0, AMI						
Line Interface	4-wire						
Speeds	2.4; 4.8; 9.6; 14.4; 19.2, 56 and 64 Kbps						
Sub-rate Framing Formatting	DS0-A, DS0-B with 5, 10 or 20 divisions per DS0						
Error Correction	Majority vote for speeds 9.6kbps or less; BCH for 19.2, 456 and 64kbps (8249 model only)						
Secondary port	As described in AT&T 62310, 62411 Addendum and TA (pass through only) TSY 000077 and TA TSY000083, a separate lower speed data circuit, which may be used for testing and maintenance. Modes are on or off.						
Distances Supported							
Primary	Secondary	Line	Loss Limit	19 Ga.	22 Ga.	24 Ga.	26 Ga.
Rate	Rate	Rate	dB	(KF)	(KF)	(KF)	(KF)
2400	---	2400	34	133.0	90.7	71.5	56.8
2400	133	3200	34	114.3	79.1	61.9	48.7
4800	---	4800	34	97.6	65.8	51.1	40.2
4800	267	6400	34	86.3	57.5	44.8	35.1
9600	---	9600	34	74.2	48.3	37.1	28.4
9600	533	12800	34	67.5	42.9	32.8	25.2
19200	---	19200	34	60.0	36.9	27.6	21.0
19200	1067	25600	34	57.0	33.9	25.1	19.9
56000	---	56000	43	60.7	35.0	24.5	17.6
56000	2667	72000	43	57.6	33.3	23.1	16.5
64000	---	72000	43	57.6	33.3	23.1	16.5
Primary Port Rate				Secondary Port Rate			
56 kbps				2,666 bps			
19.2 kbps				1,066 bps			
9.6 kbps				533 bps			
4.8 kbps				266 bps			
2.4 kbps				133 bps			
Operational Modes		Software configurable per line ocu or csu					
Standards Compliance							
AT&T TR62411		Accunet T1.5 Service Description					
TA-TSY-000077		Digital Channel Banks- Requirements for Data port Channel Unit Functions, Issue 3, April 1986					
TA-TSY-000083		Generic Requirements for the Digital Data System (DDS) Network Office Channel Unit, Issue 2, April 1986					
BellCore Pub 62310		DSO Digital Local Channel Description Interface Specification (August 1993)					
CCITT T1.107-1988		Digital Hierarchy- Format Specifications 1988					
ANSI T1.107b-1990		Digital Hierarchy- Supplement to Format Specifications (Synchronous Digital Data Format), June 1991					

## 5. BRI Card

The 826xxx line of BRI Cards offers industry standard ISDN BRI “U” or “S/T” Interfaces. Each BRI Card supports eight BRI “U” Interfaces for long line circuit provisioning, or “S/T” Interface for local provisioning. The BRI Interface provides two bearer and one data channel over two wires (1 pair). The S/T interface provides the same functionality over 4-wires (2 pair). In addition to this, each BRI “U” Interface supports 256x Zhone Technologies NTUs or Adtran 64/1218 NTUs, providing remote NTU management. With the 826361 and 826461 cards available with host release 5.1.X or above, full NTU management and ISDN switch signaling are supported.

The Basic Rate Interface “U” Interface card offers connectivity to sites located up to 18,000 feet from the integrated access system. This distance is influenced by factors such as wire gauge, bridge tap and loading patterns as described in ANSI T1.601-1992 specifications. The BRI cards are equipped with eight “U” interfaces that can carry one BRI, 2B+D channel. This will give users either two 64 Kbps or one 128 Kbps bearer channels per interface. The “U” Interface is also provides optional sealing current for maintaining wire pair performance. When used with IMACS WAN and Server Card options, the BRI card supports two transmission protocols (BRITE for the 826361/826461 models and Zhone Technologies proprietary protocol for 826070/826171 models), facilitating leased line or IDSL (2B1Q) provisioning, BRI to PRI operation and BRI (data) to Frame Relay/ATM Operation.

Either protocol allows the IMACS to extend the reach of an ISDN PBX hundred of miles away from the location of the PBX switch as shown in Figure 16. All services are passed to the remote location with no restrictions, enabling the end user or agent to use all PBX functionality as if they were locally attached to the switch. Management of this solution is transparent to the PBX programmer. All remote extensions are treated as if they are local connections. No special programming or management is necessary. For example, if there was an ISDN switch located in San Francisco, ISDN capabilities could be transparently transported across the network to a remote call center or other customer in San Ramon. There is no technical limit once connected to the network; service could be as far away as New York.



**Figure 16 - IMACS BRI Terminal Extension Application**

The two transmission protocol supports switched connectivity to ISDN capable switches and D channel signaling on either a full DS0 or multiplexed 4:1 on a single DS0. The ability to multiplex 4 channels onto one DS0 allows for more efficient provisioning. The 826361 and 826461 cards only support 3 DS0s at this time.

Another application of the BRI card is for leased line, or IDSL (ISDN Digital Subscriber Loop) as shown in Figure 18. This allows for a DDS type circuit, with 2 \* 64 kbps bearer channels over a single wire pair. The leased circuit can be any standard 2B1Q (U interface) NTU device that supports “nailed-up” (1 or 2B channels) connections and no D channel signaling for the 826070, 826171, and 826270 cards. The 826361 and 826461 cards support a standard non-direct OS/NE communication scheme or multipoint eoc (mp-eoc). The mp-eoc is used for sending operations messages between the ISDN switch and NE line units.

The requirements are specified in TR-829. The performance monitoring portion of this specification will not be implemented. For the 3-DS0 TDM, the overhead bits are transported between the LUNT and LULT as described in TR-397, and for the 4:1 TDM, this is done in a proprietary format. This allows continued customer deployment of D4 equipment as shown in Figure 17.

### Leased Line or IDSL (2B1Q)

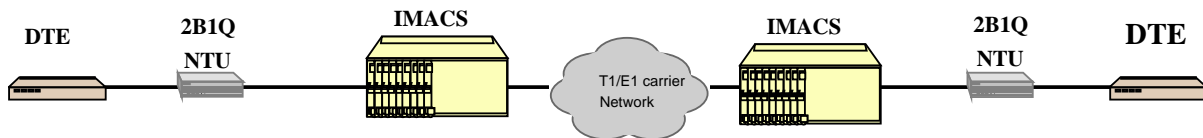


Figure 17 - IMACS BRI Card In A Leased Line or IDSL Application

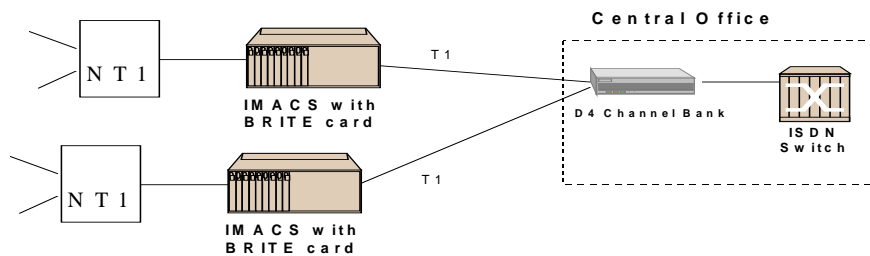


Figure 18 - Use of Legacy D4 Equipment Application

### BRI Card Models

In both cases, leased line and BRITE, B channels carrying voice traffic on the BRI card can be compressed through the ADPCM card to extend the user’s Servers. The only limitation on BRI traffic is that NTUs or NT1s must be located less than 18,000 feet from the system unit.

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The 826070 BRI “U” Card has software configurable mode operation of LT and NT. It supports up to eight leased or BRI terminal extension applications. The 826070 does not support sealing current generation or termination.

The 826171 BRI “U” Card has all of the functionality of the 826070, however, switching between the LT and NT modes must be performed by making a menu selection and changing jumper connections on the card. Also, the 826171, unlike the 826070 the card supports a user configurable sealing current of 7.5mA or 15.0mA.

The 826270 BRI “ST” Card is designed to support “S/T” 4-wire interface applications. This card provides TE, NT1 and NT2 emulation and is commonly used to provide remote extension of four-wire BRI CPE devices from an ISDN PBX.

This section outlines the applicable features in TR-NWT-000397. The LULT has the same master DSL transceiver as the LT in the ISDN switch. However, the LULT differs from the LT in several respects that deal with the DSL overhead and options for supporting multiplexing. The following list notes some of the key distinctions of the LULT from the LT.

Features of an LT like line unit (LULT):

- The LULT “functional backplane” interface is the IMACS backplane, not a switch.
- The LULT supports 3-DS0 TDM (BRITE) for multiplexing ISDN Basic Access over a carrier system. This implies appropriate processing and transport of the DSL overhead information.
- The LULT acts as a multipoint eoc intermediate slave node.
- The LULT has the option of disabling standard processing of the eoc to permit carrier transport of non-ISDN applications.
- The LULT supports generic segmented performance monitoring processing.

Features of an NT like line unit (LUNT):

This section outlines the applicable features in TR-NWT-000397. The LUNT has the same master DSL transceiver as an NT1. However, the LUNT differs from an NT1 in several respects.

- The LUNT “functional backplane” interface is the IMACS backplane, not a T interface.
- The LUNT supports 3-DS0 TDM for multiplexing ISDN Basic Access over a carrier system. This implies appropriate processing and transport of the DSL overhead information.
- The LUNT acts as a multipoint eoc intermediate slave node.
- The LUNT has the option of disabling standard processing of the eoc to permit carrier transport of non-ISDN applications.
- The LUNT only passes through NT1 power status bits or NT1-in-test-mode bits.
- The LUNT originates nib and *aib*, as well as pass on any nib values received from the customer direction and originated by a downstream line unit.
- The LUNT supports generic segmented performance monitoring processing.
- The LUNT does not require the ANSI T1.601-1992 NT1 dc termination. It provides a simple dc resistive signature for metallic testing purposes.

The 826x70 series of IMACS BRI cards are also designed to support external timing part of the standard functionality. All IMACS BRI cards support extensive built in diagnostics and tests. Loop backs can be generated on a per channel basis; with choice of loop back generation mode and loop back codes. Built in BERT tests include off, mark, space, and 1:1, 1:7, p\_1, p\_0, p\_1:1, p\_1:7.

In addition to all of the software configurable options on the BRI card itself, the BRI card has the ability to remotely manage up to eight NTUs. The NTU’s DTE interface type, data rate and asynchronous baud rate are a few options that are configurable through the IMACS BRI card interface. This further enhances network manageability by accessing all ISDN equipment from a single platform.

Table 18 describes the BRI card specifications.

**Table 18—BRI Card Specifications**

<b>Models 826070, 826171, 826270, 826361 and 826461 Basic Rate ISDN Cards</b>			
<b>Physical Characteristics</b>			
Number of ports	8		
Capacity per port	Two B (64 kbps each) and one D (16 kbps) channel		
<b>Physical Interface</b>			
Female 50-pin RJ-27X Telco connector			
<b>Electrical Interface</b>			
Model 826070, 826171, 826361 and 826461	2-wire, U-interface per ANSI T1.601		
Model 826270	4-wire, S/T interface per ANSI T1.602/ITU 1.430		
<b>826070 and 826171 Transmission Range</b>			
Wire Gauge	22 AWG (.644 mm) 23 UK SWG	24 AWG (.511 mm) 25 UK SWG	26 AWG (.405 mm) 27 US SW
Distance	26,000 ft (7.9 km)	22,000 ft (6.7 km)	18,000 ft (5.5 km)
<b>826270 Transmission Range</b>			
<b>Distance</b>			
NT p-p	Max 1500m		
NT s-b	Max. 1500m		
NT e-b	Max. 1500m. 35 m between devices		
Code	Alternate Mark Inversion (AMI)		
Rate	192 Kbps +/- 100ppm		
Timing	External and internal (software configurable)		
<b>Remote NTU Configuration Options (for 256x Zhone Technologies and Adtran NTUs)</b>			
Remote NTU not applicable for the 8263 and 8264.			
DTE Interface Type	V.36 or V.24		
<b>Procedural Characteristics</b>			
Data Protocol	Transparent up to 64kbps or 128 kbps		
Channel collision arbitration	<b>(Model 8262 only)</b> As per I.430 (D channel bit echo)		
Sealing Current	<b>(Model 8261 only)</b>		
Amperage	Jumper set-able 7.5mA or 15mA (requires -48VDC power)		
Control	Soft set-able options for start time, duration, repeat time		
Multidrop Capability	<b>(Model 8262 only)</b> Max 2		
Phantom Power	<b>(Model 8262 manual settings)</b>		
Wattage	Limited to 90 mA per port.		
<b>Software Configurable Options</b>			
Models 826070 and 826171	U termination Network (nt) or User (lt)		
Model 826270	S/T termination TE, NT point-to-Point, NT short-bus, NT extended bus		
Termination Mode for 826070 and 826171	Lease, Proprietary, Interworking, NTU-1		
Termination Mode for 826270	Lease, Proprietary Interworking		



**Table 18—BRI Card Specifications (continued)**

B-Channel Mode	None, B1, B2, B1+B2, or 128 kbps
D-subchannel	None, 1, 2, 3 or 4 (used for BRITE mode)
Sealing Current	Off or On per port ( <b>Models 826361 and 826171 only</b> )
<b>Design Standards for Models 826070 and 826171</b>	
ANSI T1.601	ISDN Basic Access Interface for Use on Metallic Loops for Application on the Network Side of the NT (layer 1 Specification) 8261, 8263
ANSI T1.602	ISDN Signaling Specification for Application at the User-Network Interface – Layer 2 Specification
ITU-T I.430	ISDN, Basic User-network Interface - Layer 1 specification
TR-NWT-000397	ISDN Basic Access Transport System Requirements
GR-000303	Integrated Digital Loop Carrier System Generic Requirements, Objectives and Interface
<b>Design Standards for Model 826270</b>	
ANSI T1.605	ISDN Basic Access Interface for S and T Reference Layer 1 Specification
ITU-T I.430	ISDN, Basic User-network Interface, Layer 1 specification
TR-NWT-000397	ISDN Basic Access Transport System Requirements
GR-000303	Integrated Digital Loop Carrier System Generic Requirements, Objectives and Interface

The following is a summary of the general requirements of the LULT and LUNT as described in the TR-NWT-000397.

Function	LULT	LUNT	Notes
DSL master transceiver (2-wire U interface)	Yes		ANSI T1.601.1992 & TR-393
DSL slave transceiver (2-wire U interface)		Yes	ANSI T1.601.1992 & TR-393
Sealing current source	Yes		
Sealing current termination			
DC Test Signature	Yes	Yes	ANSI T1.601-1992
Metallic Test Access	Yes		TR-476
Loop backs	Yes	Yes	

## 6. DSO-DP

The 825460 DSO Data Port/G.703 Data Unit (DSO-DP/G.703) is a plug-in user card for the system. The DSO-DP/G.703 provides a 64 Kbps interface to a DSO of a T1/E1 network. The card supports four (4) ports which provide a 64 Kbps interface to a DSO on a T1 or E1 WAN link. Each DSO-DP/G.703 card can be installed in any User Slot and provides four (4) DB15 female connectors.

The DSO-DP/G.703 card can be programmed to operate in either DSO-DP mode or in G.703 mode. In G.703 mode, the card supports either co-directional or contra-directional operation and this option can be set on a port-by-port basis. In DSO-DP mode, in addition to Transmit Data and Receive Data, the card can be programmed to either provide a 64 Kbps bit clock and an 8 kHz byte clock to the attached device or to receive those two clocks from the attached device.

In G.703 Co-Directional mode, the Transmit Data and Receive Data leads are supported. The clock information and the data make up a composite signal and the clock must be derived from the data stream. In G.703 Contra-Directional mode, the port provides separate Transmit and Receive Clocks to the attached device. Both clocks are 64 Kbps clocks with embedded 8 kHz Bipolar Violations (BPVs) to mark the byte boundaries.

Software-initiated diagnostics supported on the DS0-DP/G.703 card include the setting of local loop backs towards either the network or the attached DTE equipment. In addition, a remote loop back function allows the DS0-DP/G.703 card to generate four DDS-compatible latching loop back codes for the far-end OCU, CSU, DSU or DS0-DP equipment respectively. A time-out option authorizes the DS0-DP/G.703 port to automatically release the loop back after ten minutes.

### 7. BnR IP Concentrator Card

The 822860 BnR IP Concentrator card provides a means of concentrating network management data from up to 8 remote IMACS onto a single asynchronous SLIP link for connection to a NMS. Essentially the 822860 takes IP management data from the 8 B7R-formatted DS0s and concentrates it onto a single, asynchronous SLIP line which can then be connected to an asynchronous terminal server for connection to a LAN-based NMS.

Management information from remote IMACS systems can be directed to the IMACS containing the 822860 over the Facilities Data Link (FDL) or an ESF T1 link as shown in Figure 19. FDL is a 4 Kbps channel normally used to manage the T1 link. When the FDL is used to carry IMACS management data it is no longer able to carry T1 management data as well.

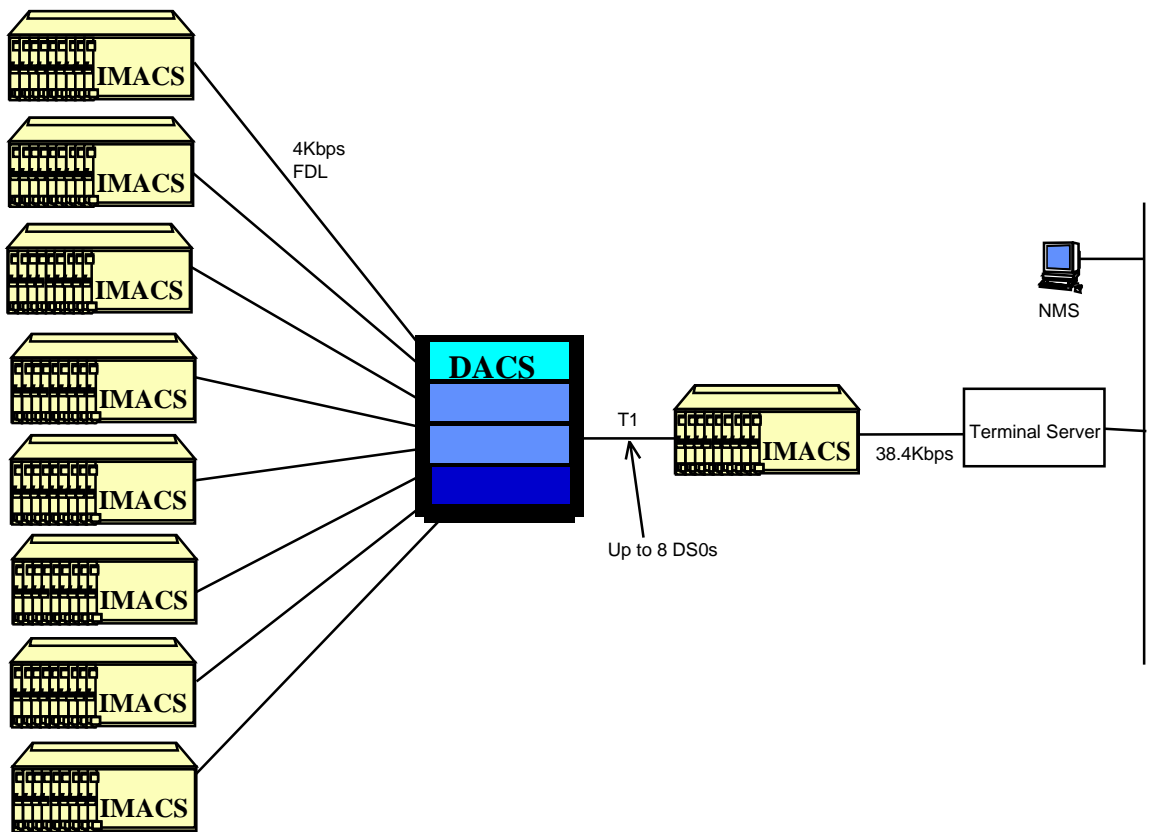


Figure 19 - IMACS Using the 822860 For Network Management

The remote IMACS systems must be configured with the TCP/IP CPU software option. Remote IMACS units send management information in IP packets over the FDL to an intervening AT&T DACS II. The DACS II can be configured to convert the IP management information from the FDL channel into a full DS0 using a link level protocol called Bit-4 Redundant (B4R). Even though the management information is only 4 Kbps it will occupy the full 64 Kbps DS0. The resulting 8 DS0s are then routed over T1 link(s) to the IMACS that contains the 822860.

Physically the 822860 is the same card as the 822060 SRU card. Both have ten RJ-48 interface ports, but on the 822860 the first eight are physically disabled and, effectively, replaced by eight “internal” ports used for the DS0s. The ninth RJ-48 port is available for maintenance and the tenth RJ-48 port is used for the aggregate SLIP line to the terminal server. Table 19 details the BnR IP concentrator card specifications.

**Table 19—B7R IP Concentrator Card Specifications**

<b>822860 External Ports</b>	
Number	2
Port 9	Available for maintenance and diagnostics (9.6kbps)
Port 10	Asynchronous SLIP port for aggregated NMS data (9.6, 19.2, 28.2 and 38.4 kbps)
Physical Interface	Female 8-pin RJ-48
Electrical Interface	RS232, ITU-T V.28
Procedural Interface	DCE—Full Duplex
IP Address	Software configurable on port 10
Subnet Mask	Software configurable on port 10
<b>Options (port 10)</b>	
Data Bits	Software configurable per port; 5, 6, 7 or 8
Stop Bits	Software configurable per port; 1 or 2
Parity	Software configurable per port; none, odd, even, space or mark
<b>Internal Ports</b>	
Number	8
Protocol	DS0 using Bit-7 Redundant (B7R or B4R) protocol
Data Rate	Preset to 4 kbps
IP Address	Of the corresponding remote IMACS
Subnet Mask	Software configurable (same for all 8 internal ports)
<b>Standards Compatibility</b>	
EIA RS232	Interface between DTE and DCE employing serial binary data interchange
ITU-T V.28	Electrical characteristics for unbalanced double-current interchange circuits

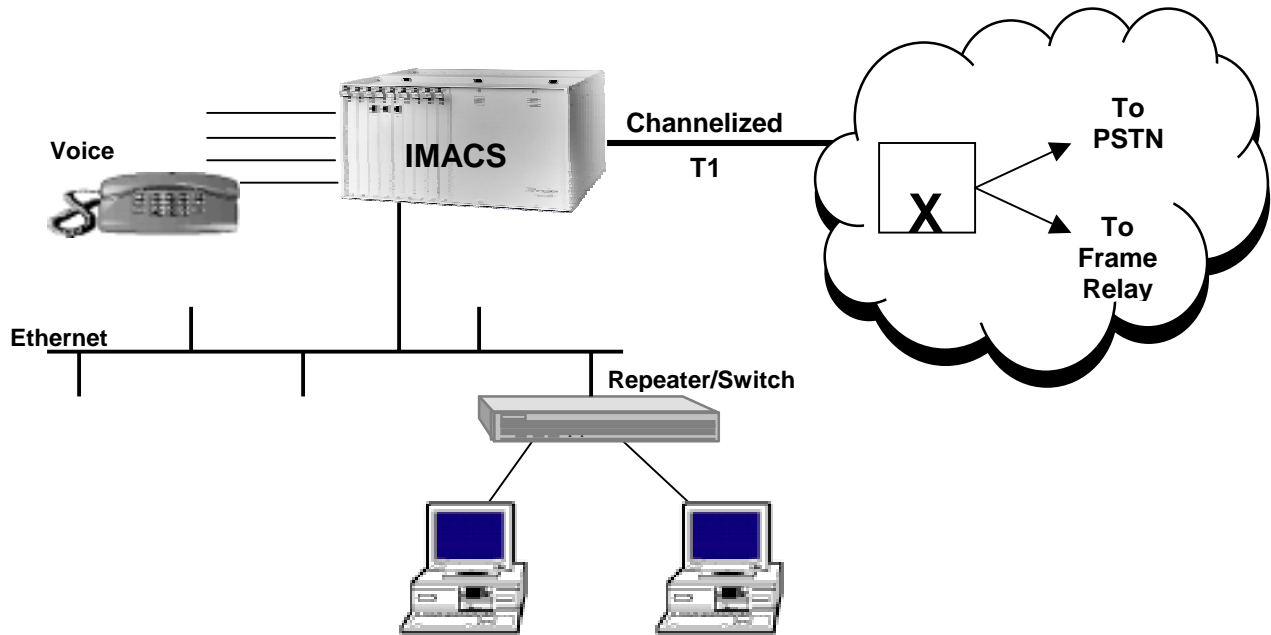
## 7. PortMaster Integrated Office Router (PM-IOR)

### Introduction:

The Zhone Technologies Integrated Office Router (IOR) integrates Internet/LAN connectivity within the IMACS and StreamLine product solutions. From a single customer premises device, the IOR card, in conjunction with other voice and data cards, will allow service providers to bundle voice, data, ISDN, and Internet services.

The IOR is a collaborative effort on the part of Lucent Technologies and Zhone Technologies. The hardware design is built from the Lucent model OR-HS, (Office Router, High-speed), and the Zhone Technologies model 821460 dual port V.35. The model number of the IOR is 828060. The IOR is a single blade device in the form factor of the Zhone Technologies modules provides a fully featured IP (IPX) router card that operates in both Zhone Technologies IMACS and StreamLine chassis. The versions for the host software supporting the IOR are the StreamLine 1.1 and IMACS 3.8/5.1.

The IOR is fully standards compliant. The card provides secure Internet access, firewall packet filtering, LAN-to-LAN connectivity, and management of the communications network.



**Figure 20 - Bundled Voice and Internet Services**

**Technical Specifications:**

Product Compatibility	IMACS 600, 800 or 900 Chassis Releases 3.8 or 5.1
Routing Protocols	Routing Information Protocol (RIP), OSPF, Lucent Technologies ComOS, UDP, ICMP
LAN Protocols	TCP/IP, IPX
WAN Protocols	Point to Point (PPP), Frame Relay (up to 14 PVCs supported, Inverse ARP
Data Rates	From 56 Kbps to 1.544 (T1) or 2.048 Mbps (E1)
Hardware Interfaces	1 Ethernet 10BaseT LAN, 1 – Asynchronous serial (115.2 Kbps), 1 NxDS0 Frame Relay or PPP WAN, 1 RJ-45 Console Port
Server Connectivity	Frame Relay or WAN Servers, PPP, Connection to WAN or ATM server
Configuration and Management	SNMP, Telnet, Out-of-band console remote management, Flash Upgrade capability

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## V. Alarm Cards

The Model 840xxx Alarm Cards provide the capability to input external alarm signals to the IMACS and to output alarm signals from the IMACS to an external device. Depending on the model, from 3 to 28 alarms may be input and from 4 to 14 alarms can be output.

The alarm input sensors are current loop detectors, with an operating range of 4 to 20 mA detection. Input sensors can be selected as active (they both supply and detect current and, therefore, can not be isolated and provide surge protection only) or passive (current sense only, completely isolated passive current detectors). When selected as passive sensors, the current source is provided externally and the sensors are Opto-isolated from the source of the alarm. If the sensors are configured as active, they can provide current source for the loop as well as current detectors, not isolated from the external loop. Depending on the model, power for active sensors can originate from network battery (usually +48 VDC) or system voltage (+12 VDC).

Input alarm conditions are reported on the Active Alarm screens, and may be logged and/or reported in the same manner as other IMACS alarms. Alarm reporting can be in the form of an ASCII string or an SNMP trap, depending on the network configuration and host software options installed.

Alarm signals are output via dual-pole, double throw relay switches. Depending on the model, these relays may be of Form A (normally open), Form B (normally closed), Form C (switched) or a combination of Form A, B and C contacts. All alarm outputs are relay-isolated. Power for these circuits must be provided externally.

The alarm contacts are connected to the external alarm equipment through one or more (depending on model) 50-pin Amphenol connectors located on the front panel of the Alarm Card.

The Alarm card model 840160 provides 4 input sensors and 4 output Form C closures. It can use either +48VDC or +12VDC to power the input sensors. If +12VDC is used, care must be exercised not to ground the circuit. The 840160 card model also has a -12VDC strapping option that allows it to be used in either European (CE Mark) systems or in US systems.

The Alarm card model 840260 provides 3 input sensors and 3 output Form C closures, one of which can only be used to signal power failure of the unit. It can use either +48VDC or +12VDC to power the input sensors. If +12VDC is used, care must be exercised not to ground the circuit. The 840260 card model also has a -12VDC strapping option that allows it to be used in either European (CE Mark) systems or in US systems.

The Alarm card model 840360 provides 28 input sensors and 14 output closures (4 Form A, 2 Form B and 8 Form C). It can use either +48VDC or +12VDC to power the input sensors. If +12VDC is used, care must be exercised not to ground the circuit. The sensors are grouped into two groups of 14 each for the purpose of selecting current source, either from the network battery or the system. Within each group, an alarm sensor can be independently configured for active or passive operation. The 8403 also has a -12VDC strapping option that allows it to be used in either European (CE Mark) systems or in U.S. systems. Additionally, it also includes a buzzer to provide an audible alarm. The buzzer can be sounded locally. This capability allows a remote site to transmit an audible alarm. The 840360 also provides a single FXS phone interface that provides a "Voice Order Wire" capability from a remote site and the voice channel can be transported being via a time slot to a central site. This connection is Loop Start only, with the "ring" signal being indicated through the buzzer, and is presented via an RJ-11 jack located on the front panel of the Alarm card. The buzzer and the phone must both be configured to use the same time slot, but only one of the functions can operate at any time.

**Table 20—Alarm Card Specifications**

<b>Model 840160, 840260, 840360</b>			
Physical Interface	Female 50-pin RJ-27x Telco connector		
Electrical Interface	4 to 20 mA Active Current Loop		
Alarm Input Modes	Active/passive (jumper selectable per port)		
Alarm Input Trigger	External circuit opening/closing (software selectable per port)		
Alarm Input Power Requirements	Network batter (+48V DC) or system voltage (+12V DC). Needed only in Active Mode		
Alarm Input Power Source through jumper selection	Selection applies to all ports in 840160 and 840260. Selection applies to a group of 14 sensors in 840360.		
Alarm Output Modes	Active/standby (software selectable per port)		
Alarm Output Trigger	Major alarm/minor alarm/any alarm (software selectable per port)		
Alarm Output Power Source	Supplied by external device		
Alarm Output Action	Open/close		
<b>I/O Ports</b>	<b>840160</b>	<b>840260</b>	<b>840360</b>
User-defined Input	4	3	28
User-defined Output	4 Form C	4 Form C	4 Form A, 2 Form B, 8 Form C
Automatic on power fail	0	1	1 Form C only
<b>Model 8403 Buzzer</b>			
Type	Piezo buzzer		
Tones	3kHz internally generated or user supplied via the network		
Modes	Local or remote (software selectable)		
<b>Model 840360 Telephone Port</b>			
Physical Interface	RJ11F		
Type	FXS Loop Start		
Loop Resistance	2400 Ohm		
Loop Current	18 mA to 32 mA		
Termination Impedance	600 Ohm		
Nominal Transmit TLP	-10.0 dB to + 5.0 dB in steps of 0.1 dB		
Nominal Receive TLP	-10.0 dB to +2.0 dB in steps of 0.1 dB		
PCM Coding	μ-Law only		
<b>Standards Compatibility</b>			
UL 1950	UL standard for safety of information technology equipment		
CEN 60 950/A2	Safety of information technology equipment including electrical business equipment		
CEN 50082-1	Electromagnetic compatibility generic immunity standard part 1 for commercial, residential and light industry.		

## VI. Server Cards

### 1. ADPCM Voice Compression Server

The 887160 ADPCM (Adaptive Differential Pulse Code Modulation) server card is designed to compress digital and analog voice traffic for transmission over wide area network links. The level of compression for an individual channel is software configurable at 24Kbps, 32Kbps or 40Kbps. This card requires a matching card at the other end to decompress the voice channels to normal 64 Kbps operation. A single ADPCM card is capable of compressing 64 channels of voice simultaneously. Since the ADPCM card is a server card, these 64 channels can be originated from a variety of interfaces, including FXS, FXO, E&M, SRU, BRI, and T1/E1. In a 3.x platform, up to two ADPCM server cards can be supported per IMACS system for a total of 128 compressed voice channels. In a 5.x platform, 3 ADPCM cards could be used to carry a total of 192 voice channels.

The sum of the compression rates for the engine pair must equal 64Kbps. A 32Kbps circuit can only be paired with a 32Kbps circuit. A 40Kbps circuit can only be paired with a 24Kbps circuit and vice-versa. The ADPCM server card can also pair a low speed asynchronous data transmission (19.2Kbps or less) from an SRU port with a 40kbps engine. This data path will occupy a 24Kbps engine. Group II FAX is supported in 32Kbps channels and Group III FAX is supported in 40Kbps channels.

Modem support up to 4.8Kbps, and V.32bis to 9.6Kbps is supported in 32Kbps channels. Modem speeds up to 12Kbps, and V.32bis speeds up to 14.4Kbps is supported in 40Kbps channels. Modem data is not supported in 24Kbps channels.

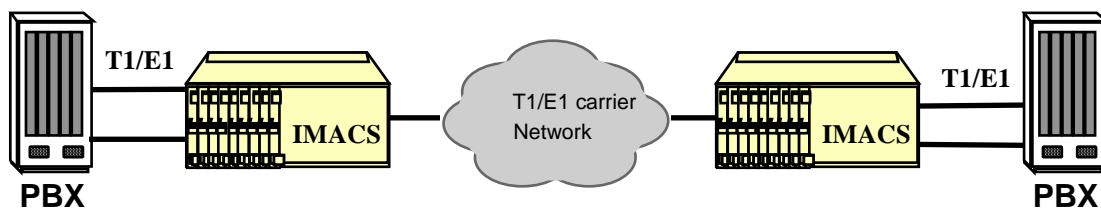
The ADPCM card supports Transition Signaling as defined by ANSI T1.302-1989 with the exception of the Alarm bits. ANSI T1.302 specifies signaling at the 32Kbps compression rate. The ADPCM card uses this scheme for 24Kbps and 40Kbps although it is not included in the standard.

The ADPCM card can be used in a variety of applications to reduce the number of transmission lines for efficient transport of voice traffic. It can be used in:

- PBX-to-PBX trunk application
- Automatic Call Distribution application
- Efficient wireless base station/hub application

### **PBX-to-PBX Trunk Application**

Figure 21a shows the IMACS with an ADPCM server is used to compress two T1 or E1 PBX-to-PBX trunks into a single trunk. The voice from each PBX is connected via a digital T1 or E1 connection to the IMACS. The voice channels are routed to the ADPCM server, where each voice channel is compressed to 32 Kbps. The compressed voice is routed to the outbound T1/E1 link to the other IMACS unit, where it is decompressed and placed back into two T1 or E1 trunks to the remote PBX. PBX-to-PBX trunk lines can be compressed 2:1 to reduce leased line charges. The application is also valid for analog PBXs and key systems.



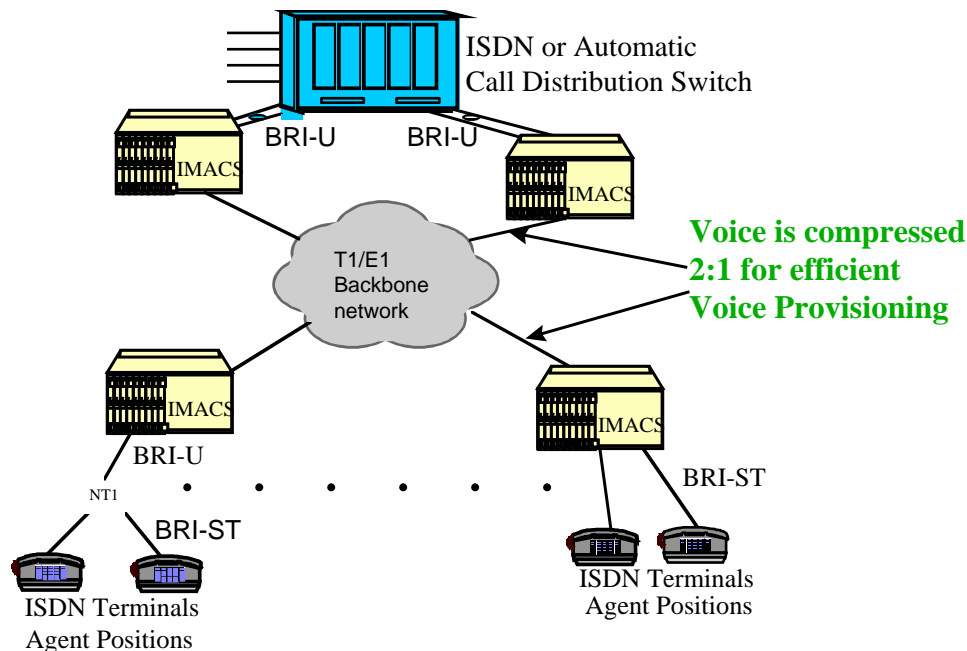
**Figure 21a - IMACS Using ADPCM for PBX to PBX Application**

**Automatic Call Distribution Application**

The ADPCM server can be used to reduce leased line charges in automatic call distribution or remote call center applications by increasing the number of voice circuits supported on a single T1 or E1.

The application shown in Figure 21b illustrates an ISDN-based automatic call distribution system. The IMACS is used to provision BRI remotely via BRITE (BRI Terminal Extension). With the IMACS, ten BRI circuits can be extended to remote locations over a single T1 line, and 13 over a single E1 line. The IMACS is able to do this by placing the 2B+D signal into 2.25 time slots (1 for each B, and .25 (16Kbps) for the D channel).

The ADPCM server is used to increase the number of BRI circuits supported per T1 or E1 by compressing the B channels in voice only applications. This means that a 2B+D channel can be transported in 1.25 time slots (.5 for each B, and .25 for the D channel). Hence, 19 BRI circuits (38 voice channels) are transported over a single T1 and 24 BRI circuits are transported (48 voice channels) over a single E1.

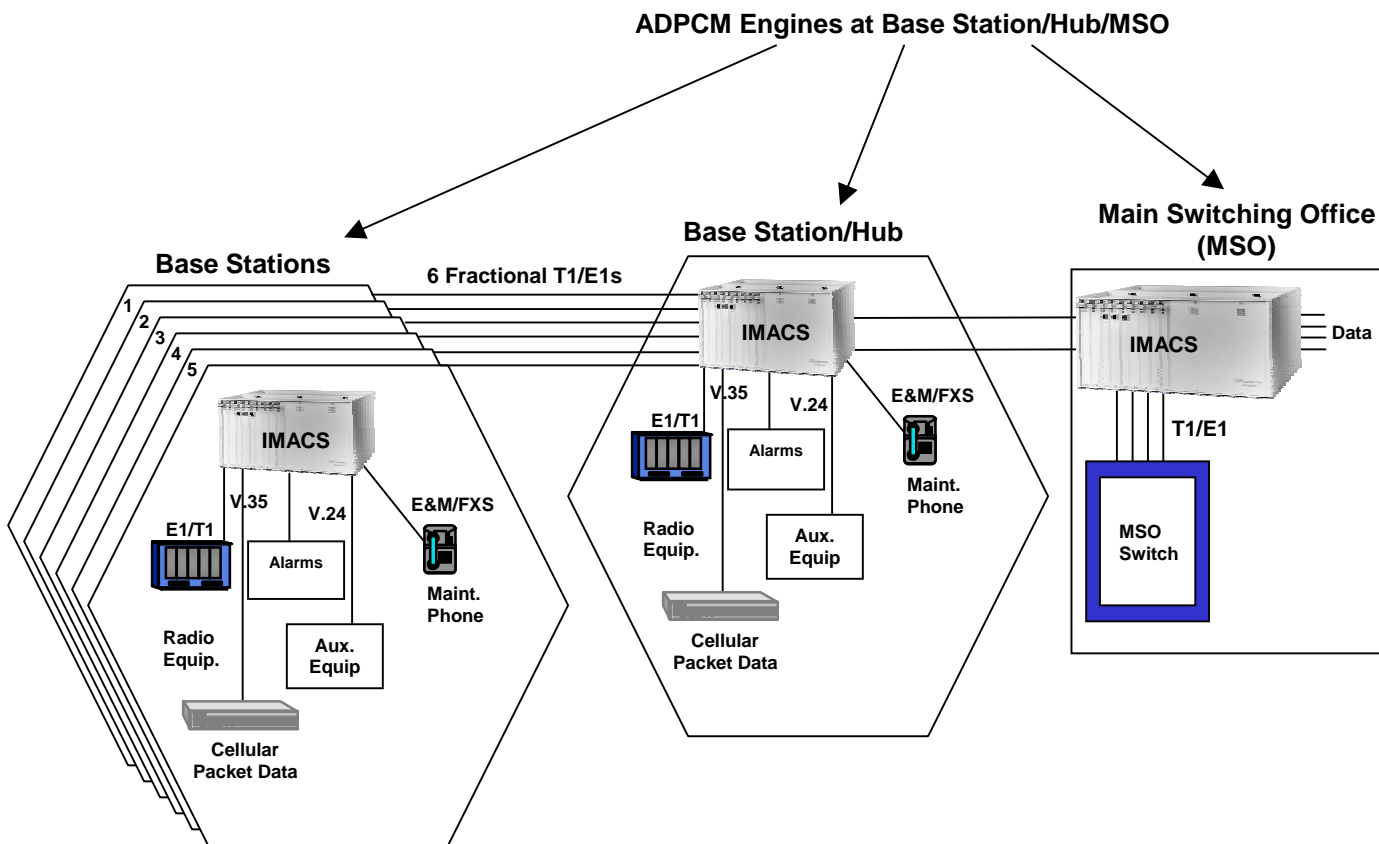


**Figure 21b - IMACS In An ISDN-based ACD System**



**Wireless Base Station Application**

In the application shown in Figure 22, the IMACS is used as a channel bank at each of the remote Base Stations. In each of the stations, the IMACS is connected via T1/E1 or Analog voice ports to the radio transmission equipment. The voice circuits that are destined for the switching center are sent to the ADPCM voice compression server at each base station. This compressed voice traffic is then groomed with other Base Station data traffic and transmitted over Fractional T1/E1 lines. An IMACS is used at a central location to groom the Fractional T1/E1 lines into two T1s or E1s. These two lines are connected to the Switching Center where an IMACS with two ADPCM servers is used to decompress the voice circuits and send them to the switch via four T1s or E1s.



**Figure 22 - IMACS In A Wireless Base Station Application**

Base Station to MSO voice traffic can be compressed to efficiently backhaul traffic, which reduces line charges. An alternative to this application would be to transport the voice from the Base Station to the Hub uncompressed over the Fractional T1s and E1s and then perform the voice compression function in the IMACS at the hub. Table 21 describes the ADPCM Server card specifications.

**Table 21—ADPCM Server Card Specifications**

Input Voice Channels	Can originate from any 2-wire or 4-wire voice card or from a DSO on a WAN (E1/T1 or HDSL) interface. $\mu$ -Law & A-Law 64Kbps PCM compatible on a per channel basis
Input Sub-rate Data	SRU data traffic at 19.2Kbps or less can be carried on a 24Kbps sub-channel
Input BRI traffic	B channel voice traffic can be compressed at any of the configurable rates
Modem Data Support	Transcoder rate: 24, 32 or 40 Kbps; Modem Data: none, up to 4.8Kbps, V.32 to 9.6Kbps, up to 12Kbps and V.32 bis to 14.4Kbps
Fax Support	Transcoder rate for fax: 24, 32 or 40 Kbps; none, Group II and Group III fax
Voice Quality	As measured by Mean Opinion Score (MOS) analysis, a subjective evaluation with a range of 0 (poor quality) to 5 (good quality). Toll quality voice is accorded a MOS of 4.0 24Kbps transcoder rate MOS is 3.6-3.8; 32Kbps transcoder rate MOS is 4.0-4.3 and 40Kbps transcoder rate MOS is 4.0-4.3
Echo Cancellation	Non provided—typically not required

Signaling	Transmitted in-band utilizing CAS transitional signaling, as per ANSI T1.302—1986 for 32Kbps and modified for use with 24Kbps and 40Kbps. Note Robbed Bit Signaling Alarm Transmission, as specified in ANSI T1.302a-1989 is not supported
Maximum Card Count	3 (with 3.x CPU-2 active with 1 redundant or 3 active, 5.x CPU 3active)
Transcoder Operation	Compliant to G.761 Alarm Indication and Fault Handling
Standards Compliance	ANSI T1.3021989, ANSI T1.302a 1992, ANSI T1.3031989, CE EN 500- 81-1, CE EN 500-82-1, CE EN 60950/A2, ITU-T G.721, ITU-T G.723, ITU-T G.726 12/90

## 2. ISDN Primary Rate Interface (PRI) Server

The PRI Server Card provides flexible access and routing of PRI-based ISDN services. The ISDN PRI Server can be used for enabling applications such as Video Conferencing, Video Broadcast, ISDN Grooming, and Fractional PRI provisioning. The PRI Server card supports B channel bandwidth of 56K, 64K, 384K, 1536K and Multi-Rate speeds where available. Multi-Rate speeds allow the PRI server card to select calls in increments of 64Kbps. In areas where Multi-Rate is not supported by the local ISDN switch, an Inverse Mux (IMUX) Server Card should be used to aggregate individual 64Kbps calls.

The PRI card can be utilized with the 8213 Switched HSU Card for RS-366 and V.25bis bandwidth on demand dialing. Additionally, regular HSU cards can be used for DTR dialing. The PRI server card supports both the Network and User side protocols associated with ISDN PRI services and therefore the IMACS can be used to both originate and terminate ISDN calls.

The following components make up the BRI/PRI solution:

- One 881160 Multi-Server Card
- One 65100 BRI/PRI Service Translation Software Package
- Optional WAN Interfaces with associated Line Interface Modules
- Optional ISDN ‘U’ and ‘S/T’ Interfaces

Three ISDN PRI Server Cards are supported:

- 8840A ISDN PRI Server Card with 1 D Channel
- 8840B ISDN PRI Server Card with 2 D Channels
- 8840C ISDN PRI Server Card with 8 D Channels

The cards provide flexible access to PRI-based ISDN services such as Switched 384, Switched T1, and Switched 56/64. The PRI Server Card (PRI card) provides both local D channel origination and termination and D channel consolidation. The PRI Server card is available in three different software versions based on the number of D channels (1, 2, or 8) to be supported. It offers a perfect alternative to standalone ISDN access devices when other “non-ISDN” voice and data services must be consolidated in addition to ISDN services.

The 8840B and 8840C ISDN cards can be simultaneously connected to several network and user side ISDN PRI facilities. The ISDN PRI card provides D channel support of both the network side protocol and the user side protocol. Typically, the IMACS with an ISDN PRI card, supplies the network side protocol on a D channel connected to a PBX, and provides the user side protocol on the D channel connected to a carrier switch.

The 8840C ISDN PRI server card, which supports eight (8) D-channels can be configured to route calls from a PBX, multiple PBXs, and DTE devices to multiple ISDN service providers. The 8840x ISDN PRI Server does not support BRI-to-PRI translation. This application is supported by the 65100 ISDN BRI-PRI translation software running on an 8811xx ACS card.

### **NFAS (Non-Facility Associated Signaling)**

All ISDN PRI cards can be configured to support NFAS (Non-Facility Associated Signaling). The IMACS limit for NFAS is 191B+D in T1 environments (8 times 24 minus 1 D channel) and 239 B+D in E1 environments (8 times 30 time slots minus 1 D channel).

A basic ISDN PRI facility is a T1 link that consists of 23 B channels and 1 D channel (23B+D), or an E1 link that consists of 30 B channels and 1 D channel (30B+D). Note that one time slot on any E1 link is reserved for framing and maintenance use, and is neither a B channel nor a D channel. The D channel provides signaling for all of the (23 or 30) B channels on the facility carrying that D channel.

However, many ISDN applications have relatively low call rates (i.e., the D channel is not very busy), but need more than 23 (or 30) B channels to carry user (bearer) traffic. In these cases, a D channel can be set up to perform signaling not only for the B channels on its own facility, but also for B channels on other facilities (i.e., other T1/E1 WAN links). When a D channel is so provisioned, it is considered to be performing non-facility associated signaling (NFAS). The IMACS is limited to 8 WAN links. Thus the IMACS limit for NFAS is 191B+D in T1 environments (8 times 24 minus 1 D channel) and 239B+D in E1 environments (8 times 30 minus 1).

Although IMACS supports NFAS, it can only be implemented within private networks or in public networks where the service provider supports it. Within EC and EFTA countries NFAS is considered an EC-MOU2 supplementary service, which is still at the discussion stage and therefore is not supported by any of the European Service Providers.

### **Remote Login**

In addition to carrying ISDN signaling information, the D channel can also be used to log into a remote system unit to check card status, and perform necessary system maintenance. This unique application does not require B channel allocation. The ISDN call is placed on the D channel to the ISDN network and routed to the D channel of the remote unit. Coordination with the ISDN facility provider is necessary to obtain the number for the remote system unit.

## Applications

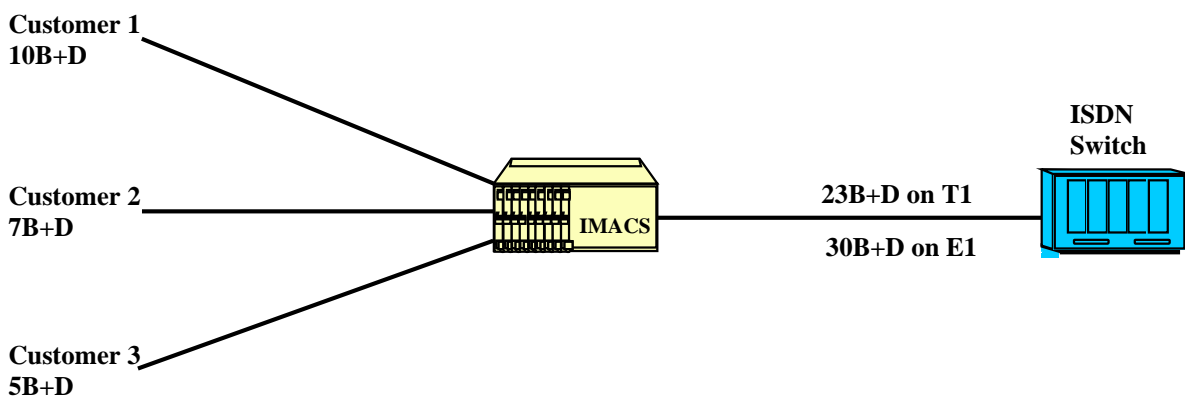
The ISDN PRI Server card can be used in a variety of applications:

- Fractional ISDN PRI provisioning
- Video conferencing
- Integrated ISDN access with SINA
- Video Broadcast
- Router with redundant trunk routing via ISDN
- Router adding incremental bandwidth
- PRI to FXS

### Fractional PRI Provisioning

An IMACS equipped with a 8840C PRI Server card is used to groom multiple fractional PRI circuits into one or more PRI circuits for backhaul to an ISDN switch. Perhaps a customer may not need the entire bandwidth delivered by a PRI circuit. The optimal alternative would be to purchase a fractional PRI service delivered over a regular T1 or E1 circuit. When a service provider has multiple fractional PRI customers, the service provider can deploy the IMACS to groom the multiple fractional PRI circuits into one fully utilized PRI T1/E1 circuit, which is back hauled to the switch. This concentration of PRI circuits reduced back haul costs for the service provider, and conserves T1/E1 ports and D-channels on the ISDN switch itself.

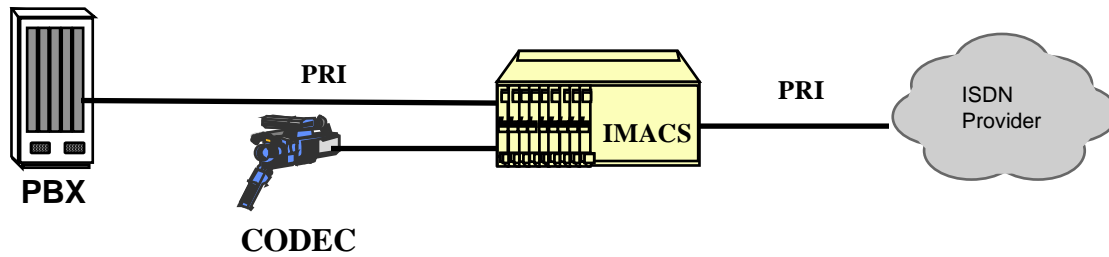
Figure 23 shows that three customers are subscribing to ISDN services. Each customer is using a fractional PRI service. Each customer could be directly connected to the ISDN switch, which would consume three fractional T1/E1 circuits, and three D channels. Instead, the 3 fractional ISDN circuits are connected to a PRI Server equipped IMACS. The PRI server grooms the B channels in the three fractional ISDN circuits into one circuit. It also grooms the three D-channel circuits into a single D channel that is routed to the switch. The IMACS benefits in this application include saving on back haul costs, switch port costs and switch system resources.



**Figure 23—Fractional PRI Provisioning Using IMACS**

### ISDN Video Conferencing and Video Broadcast

The IMACS is used to connect video-conferencing equipment to an ISDN PRI line. In Figure 24, a video CODEC is sharing a PRI line with an ISDN PBX. The IMACS is simultaneously routing calls on a call by call basis to either the PBX, the CODEC, or out to the network. The video-conferencing equipment can be connected via an RS-449 connection with an RS-366 dialer or directly to the IMACS via an ISDN PRI interface. A connection to the IMACS via the RS-449/RS-366 combination would require the use of a switched HSU card in the IMACS.

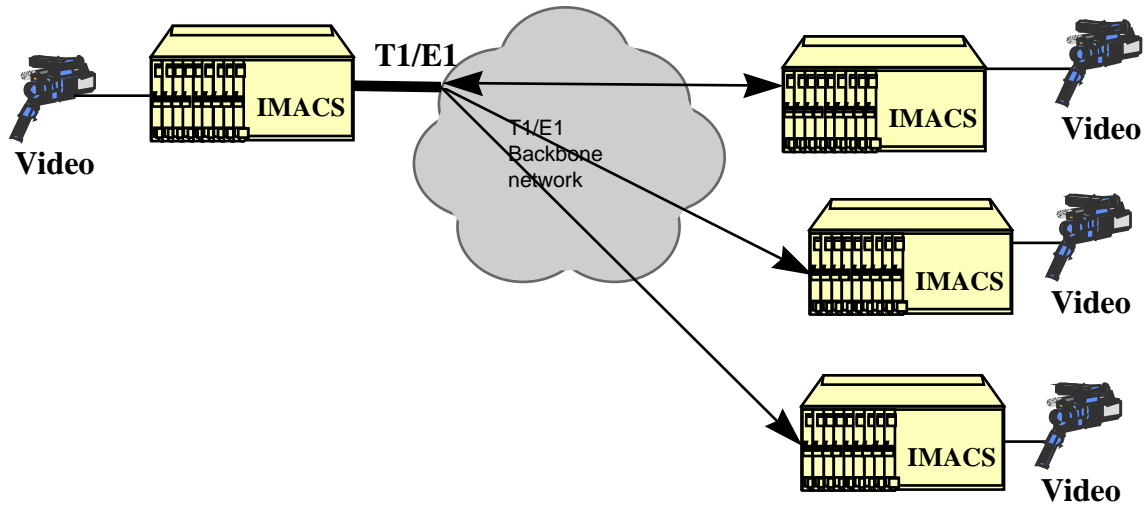


**Figure 24—Video Conferencing System and PBX Sharing A PRI Line**

By grooming the PBX and CODEC PRI circuits onto a single, outbound PRI facility, the IMACS utilizes Dynamic Bandwidth Allocation (DBA). The PBX would seize B-channels on a call-by-call basis, utilizing one B-channel for every call. The Video Codec would request a pre-determined number of B-channels. For example, if a 384K call was required, the Video CODEC requests a single 384K circuit, which would consume six of the B-channels. If the ISDN service supports 384K calls, or Multi-Rate services, and the bandwidth is available, the ISDN server card will connect the Video CODEC to proper time slots. If the bandwidth is not available, the IMACS rejects the call. If 384K-bonded service is not supported by the ISDN service, the IMACS must be equipped with an Inverse Multiplexer (IMUX) server card. The IMUX server card is capable of bonding or aggregating multiple 64K circuits into a single larger capacity circuit.

Inbound calls would be handled in a similar manner. All inbound calls would be screened by the IMACS' PRI Server card. Calls destined for the PBX would be routed to the PBX, and calls destined for the Video Conference Unit would be routed there. If the video Codec was in use, the IMACS will inform the ISDN service that the unit was in a busy condition.

A unique feature of the PRI Server card is its ability to combine multiple ISDN circuits to form a Video Broadcast. This feature is very useful for distance learning applications where a central site broadcasts video to multiple remote locations. In this application, an IMACS equipped with a PRI server card takes a video source and makes a two-way connection with the first remote IMACS video-conference site as shown in Figure 25. Once that connection is established, the host IMACS calls up to a total of 32 additional remote video-conference sites and distributes the same outbound video feed to all of those sites. These additional sites are in a view-only mode and do not distribute video back to the central site. The loss of one or more of the remote sites will not affect the broadcast to the other sites. This application can be upgraded to allow two-way audio to each of the sites though the use of analog voice cards.

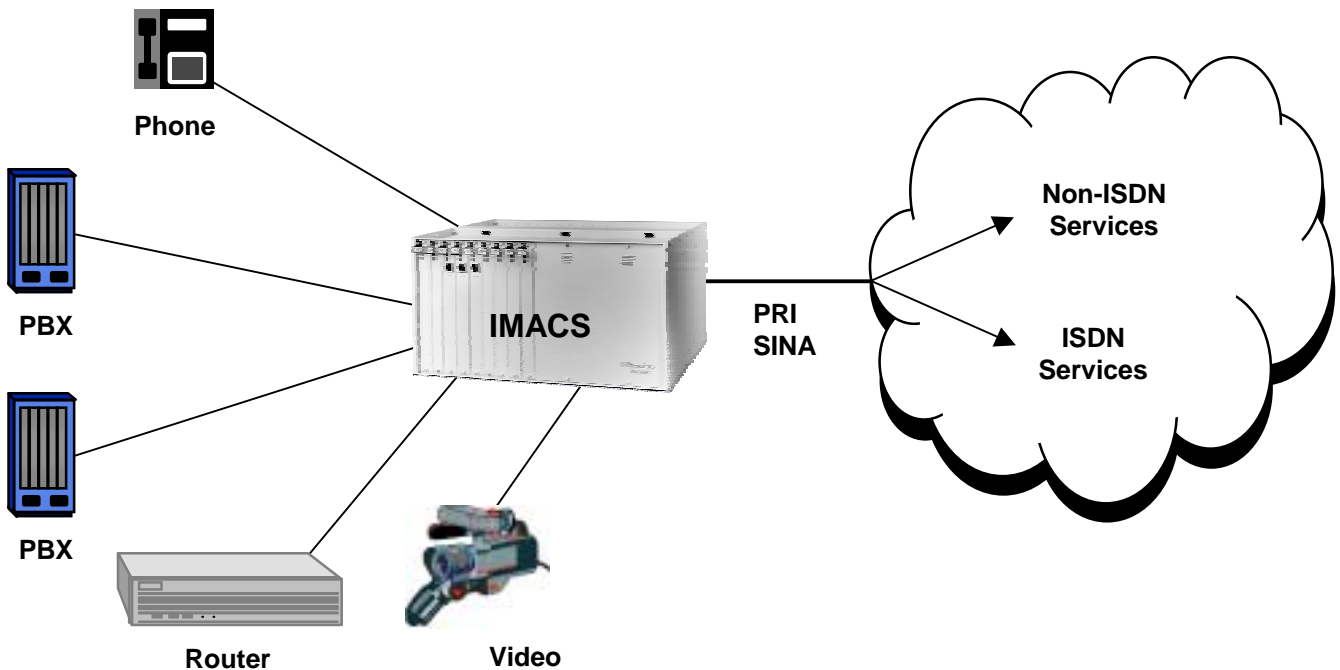


**Figure 25—IMACS in Video Broadcast Applications**

**Integrated ISDN Access with SINA**

The IMACS is used to support both ISDN and non-ISDN services over the same T1/E1 circuit. This multiplexing of leased line and ISDN services is commonly referred to as Static Integrated Network Access (SINA).

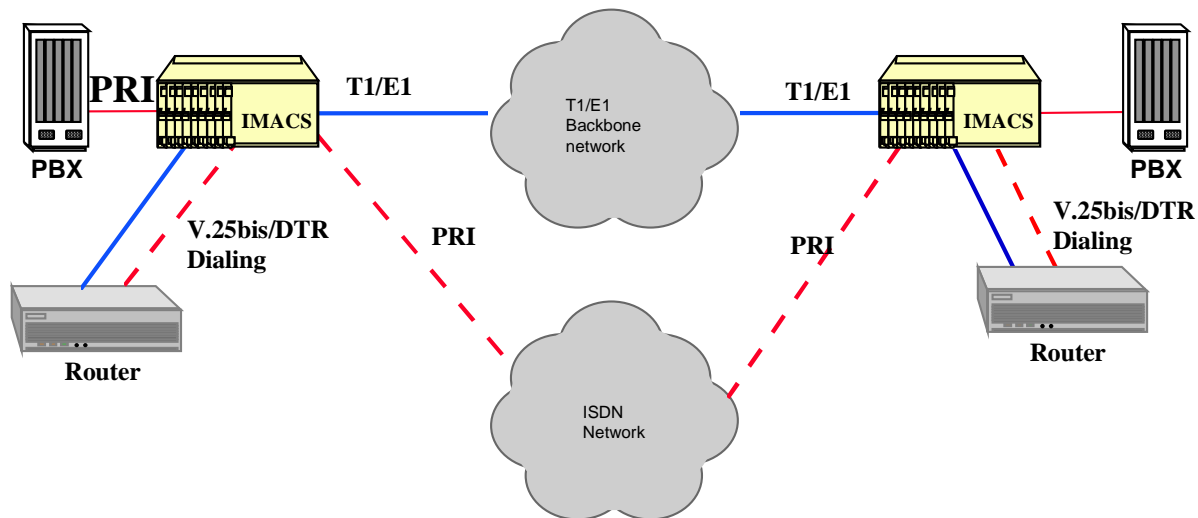
As shown in Figure 26, several non-ISDN applications are used including analog voice and data applications, low speed SNA data, and non-ISDN PBXs. Several ISDN based applications are being used including video-conferencing, dial routers, and an ISDN PBX. The non-ISDN circuits are groomed onto the T1/E1 circuit for delivery to the network. ISDN applications are sent to the PRI Server card for concentration and are switched onto the same T1/E1 circuit in time slots appropriate for switched ISDN calls. Within the network, these circuits are groomed via a cross-connect to the appropriate services.



**Figure 26—IMACS Using SINA for ISDN and Leased Line Traffic****Data Backup and Bandwidth on Demand**

The IMACS with a PRI server is used to back up data networks in the event of a circuit outage. In the example shown in Figure 27, an IMACS is used to connect a router to a leased line circuit. The PBX is using the IMACS equipped with a PRI server card to connect to the PRI circuit. In normal operation, both the voice traffic and the data traffic simply pass through the IMACS. In the event that the leased line circuit is dropped the router will sense the loss of data and attempt to dial bandwidth via its second line. This second port can be configured on the IMACS to accept dial commands using the V.25bis, or to dial a pre-determined number when the IMACS senses DTR. When the router senses that a failure has occurred, it will request bandwidth from the IMACS. If the PRI does not have enough bandwidth to satisfy the router's request, the IMACS rejects the call. The router will then request another call with smaller bandwidth requirements and will monitor the original leased line for presence of data. When the router detects that the leased line is back in operation, it will switch its transmission path back to its original state, and drop the ISDN connection.

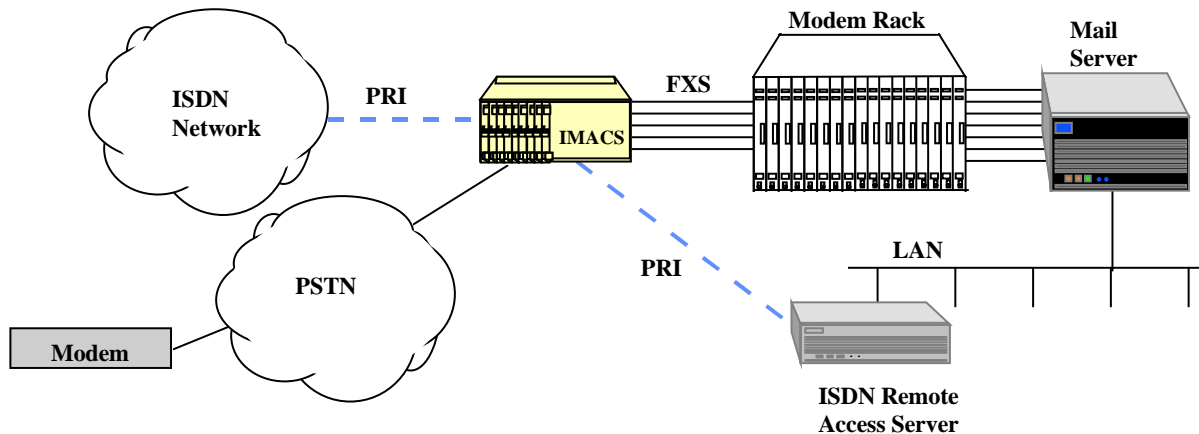
This configuration is utilized to provide bandwidth-on-demand during peak utilization times such as nightly backups. With this application, the PBX utilizes the PRI bandwidth on a call-by-call basis during the day, and the router utilizes the leased line. At a pre-determined time-of-day, the router would request all or the majority of the PRI bandwidth. The router utilizes both the leased circuit and the ISDN circuit for a set period of time. For example, the PRI line would be used during the day to carry the voice calls, at night the PRI line would be used to increase the bandwidth available for the nightly computer systems backup. The router routes packets over both the leased line and the PRI line until the backup was complete. At that time, it would disconnect the PRI call.

**Figure 27—IMACS Using A PRI Server Card For Data Backup**

**PRI to FXS Termination**

The IMACS is used to connect calls to an analog modem rack as shown in Figure 28. This application is usually used to terminate a mix of ISDN originated calls and analog modem originated calls to the same destination. This is common in remote access applications where there is a need to support both existing analog modem applications and new digital ISDN connections over the same network facility. End users can migrate as needed from analog modems to ISDN, sharing the same facility, and maximizing utilization of network bandwidth. The IMACS receives all calls, examines the called number and routes the analog modem calls to the FXS hunt group. ISDN data calls are routed directly to the ISDN remote access server. This application only works for inbound calls since the modems in the rack cannot be used to dial out through the IMACS over ISDN.





**Figure 28—PRI to FXS Termination**

## Routing Capabilities

### Call Routing

An IMACS system can be simultaneously connected to several Network and User side ISDN PRI facilities and to a user's data terminal equipment such as a video codec or LAN router. DTE is usually connected to the system's HSU cards.

Any call originating from a HSU port (with the exception of the Switched HSU card), must be associated with a call profile. The call profile specifies which D channel is to carry the call. Any device attached to an HSU port that is able to receive incoming calls is assigned a unique number that allows the system to route the incoming call to it. Optionally, a shared hunt group phone number can be assigned to the same HSU port.

When an incoming call is received by the system, it first scans all of the primary HSU or FXS phone numbers to attempt a match. If no match is found, the system then searches the list of hunt group numbers to find a match. If a match is not found, the system will begin searching the D channel routing tables, for routing of the call to a PRI line. If no matches are found, the call is rejected.

### Local Routing

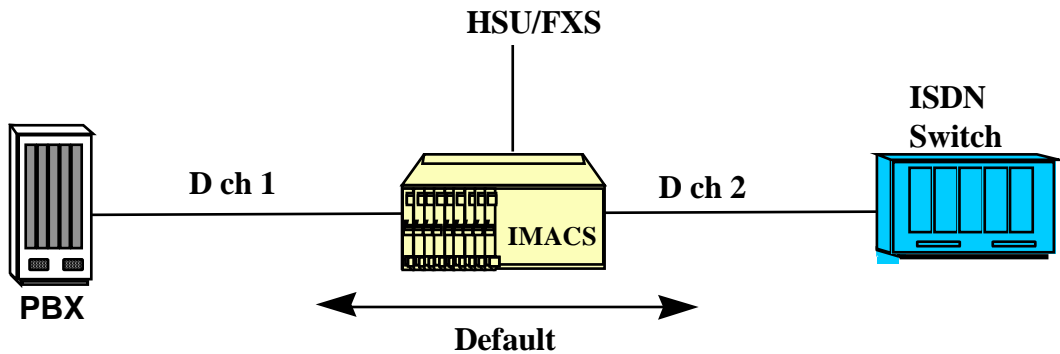
From an IMACS perspective, devices such as video codecs or PBXs that are directly attached to the system (i.e. do not pass through a carrier network to connect to the system) are considered "local" devices. All HSU ports are local devices. Any PRI device, such as a PBX, that is connected to an IMACS D channel configured for "Network" side is a local device. Local routing is defined as call routing between any two devices. Calls can be locally routed from a PRI to a PRI (for example, from a local PBX to another local PBX), or from an HSU to a PRI. HSU to HSU call routing is not supported.

Incoming calls are routed based on the called phone number, not on call profiles. Because the IMACS system does not provide billing information, users may want to prohibit local routing of D-channels. For example, a carrier may require that all calls are routed through the CO based switch for billing purposes. To provide for this, local routing can be disabled.

If local routing is disabled, any call coming into the system on a network side (i.e. local) D channel will be routed only to a user side D channel based on the called number. Even if the called number matches, such a call will never be routed to an HSU port or a network side D channel when local routing is disabled. When local routing is enabled, then any call coming in on a D channel will be routed to the first matching phone number, regardless of whether or not the match is for a local device.

**Bi-directional Default Routing**

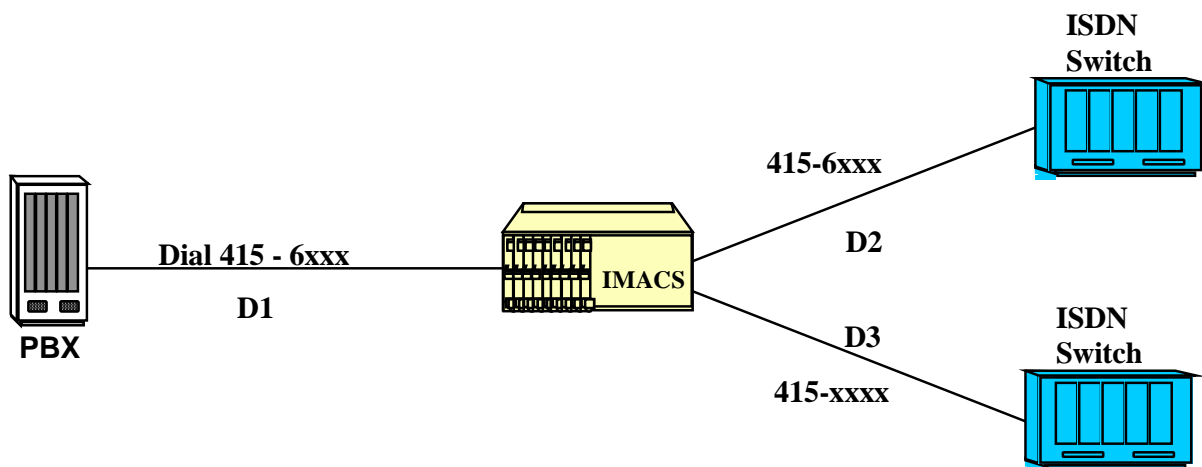
Bi-directional Default Routing is provided for automatic routing when a node is configured with two Primary Rate D channels as shown in Figure 29. In two channel systems, the user does not have to configure any routing information, as all calls received on one D channel are automatically routed to the second D channel. The user only needs to enter routing information for those calls destined to a local HSU or FXS ports.



**Figure 29—Bi-Directional Default Routing**

**Alternate Routing**

Alternate routing is provided for calls to take an alternate path in the event of a congested or failed primary trunk. When there are more than two Primary Rate D channels, phone numbers can be assigned to more than one D channel. Calls placed or routed through the PRI server will now have an alternate route if no bandwidth is available on the first specified path. Alternate routing will also take place in the event of a failure of the first Primary Rate circuit. In the example shown in Figure 30, the call from D1 is usually routed to D2, as the D channel numbering is more specific. However, if the D2 trunk become congested or go out of service, the call will be routed to D3.



**Figure 30—Alternate Routing**

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## DPNSS Trunk Routing

Digital Private Network Signaling System #1 (DPNSS) is the predominant Common Channel Signaling scheme used in the United Kingdom for private inter PABX communications. DPNSS Trunk Routing provides low delay for multi DPNSS channel provisioning off a single E1 DPNSS aggregate. This is achieved by mapping the B channels to dedicated time slots rather than to hunt groups, which in turn provides efficient D channel grooming and subsequent billing.

## 3. Management Channel Concentrator (MCC) Server

The Management Communications Concentrator (MCC) provides management connectivity to remote IMACS systems. It can concentrate the TCP/IP management traffic from up to 131 remote IMACS networks onto either a single, local 10 BASE-T Ethernet port, or encapsulate the information as per RFC1490 on to a Frame Relay link. There can be up to 3 MCC server cards in an IMACS chassis in non-redundant operation. The following hardware and firmware must be included in an IMACS to add MCC Server operation:

- 880360- CPU Control Card with 8 T1/E1 Cross Connect (redundant-capable)
- 892260/892360/892460 - 8 T1/E1 Interface card w/ 128K NVRAM.
- 881360 - Advanced Communication Server (ACS) with 131 logical ports
- 60511 - Host Firmware version 5.0.x
- 63110 - MCC Server firmware

The following protocols are supported by the MCC:

- Ethernet Media Access Control Protocol (MAC)
- Address Resolution Protocol (ARP) (RFC 1122)
- Internet Protocol, version 4. (IP) (RFC 791, RFC950, RFC 1122)
- Internet Control Message Protocol (ICMP) RFC 792
- User Datagram Protocol (UDP) RFC 768
- Routing Information Protocol (RIP) (RFC1812)
- Frame Relay (RFC1490)

The MCC provides routing between the b7r formatted ports and Ethernet, allowing IP management data of remote IMACS' to be terminated onto a local area network. The MCC can route between any of its interfaces depending on its configuration. In addition to the B7R protocol used for T1, and B4R used for E1, a full DS0 is also provided on all ports. B7R and full DS0 cannot be combined unless configured in groups of 64.

The MCC offers far more interfaces and functionality than the BnR, thus replacing it and the terminal server required to bring the IP traffic to a LAN. The MCC can be configured to use unnumbered or numbered interfaces. If unnumbered interfaces are used, MCC is accessed through the global Ethernet address regardless of what interface is used. If numbered interfaces are used, each interface has a local IP address. When unnumbered interfaces are selected, the IP address entered on the port is the IP address of the remote device. Similarly, when numbered interfaces are used, the IP address entered for any given numbered port is the IP address of the local port itself. Unnumbered interfaces help conserving IP addresses as only one address is used per interface. This addressing method may not be compatible with HP Openview.

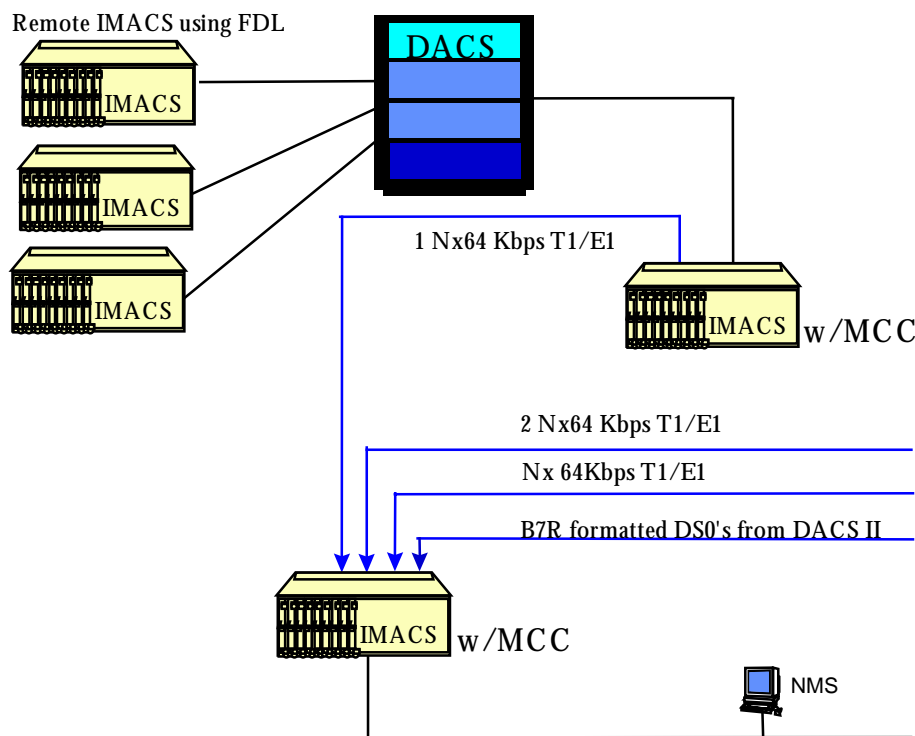
The MCC routes IP datagrams between all of its interfaces, based on each datagram's IP destination address. Datagrams are directed (or routed) to the interface carrying the sub-net to which the datagram belongs or is being transported to, according to the content of the routing table. The routing table may be supplied with dynamic routes from the Routing Information Protocol (RIP) when enabled. If no match is found in the routing table, a default route can be designated to direct all unresolved datagrams to a specific interface.

Initial configuration of the MCC can be made through the local VT100 port. When a working interface is established to the CPU hosting the MCC, subsequent configurations can be done remotely via SNMP/TELNET. All

configurable port parameters are permanently stored in NVRAM and downloaded to the card during startup. Statistics are available on a per port and protocol basis.

IP-based management information from IMACS clients is typically provided to the MCC by a Digital Access and Cross-connect System (DACS) as Bit Seven Redundant (B7R) or Bit Four Redundant (B4R) DS0 channels on a T1 or E1 link. The MCC routes IP packets among the 131 available WAN interfaces, the local host CPU and Ethernet. Each interface represents a separate network or subnet as specified by the IP address and Netmask combination. Three of the 131 are high-speed interfaces that can either be configured as Nx64 kbps (N=1 to 24 for T1 or 1 to 31 for E1). Those interfaces can independently be configured for the Frame Relay protocol or for transparent HDLC. The 128 lower-speed WAN interfaces can be configured in groups of 64, to either be in BnR mode.

Figure 31 shows FDL channels from the remote IMACS a, b, c, and fed into a DACS II for translation into multiple B7R encoded DS0 channels. IMACS I, connected to the DACS II, routes IP datagrams to IMACS II through the alternative high-speed interfaces. IMACS II in turn routes datagrams to the Local Ethernet to the NMS.



**Figure 31—MCC In A Multilevel Concentration Application**

## 4. ACS-FRS Advanced Communication Server - Frame Relay Server

The 881160 FRS card concentrates multiple N x 56K or N x 64K frame relay data streams onto one or more Nx56/64K links of the IMACS. In addition to frame relay concentration, the card encapsulates data for Nx56/64K HDLC or SDLC data streams. RED frames can be discarded rather than forwarded to the FRS end-point screen. The ACS-FRS uses flag sharing, meaning that the closing flag of one frame will be the opening flag of the following frame.

The frame relay server software (v1.8) runs on the card, which provides up to 68 logical ports. Up to 128 permanent virtual circuits (PVCs) can be configured on a single card. The aggregate speeds of all ports associated with each FRS cannot exceed 8 Mbps.

The FRS has a maximum of 68 ports. When all four “C” ports are used to interface to other cards such as the HSU, 64 ports are left to interface to the external cross-connect.

The FRS card also maintains detailed performance statistics both on a per port and a per PVC level.

### Frame Relay Server Specifications

There can be up to three Frame Relay server cards in an IMACS chassis in non-redundant operation. The Frame Relay Server performance figure of 4000 Frames/Second was obtained using 64 byte frames. The following hardware and firmware must be included in an IMACS to add Frame Relay Server operation:

- 880360- CPU Control Card with 8 T1/E1 Cross Connect (redundant-capable)
- 892360/892460 - 8 T1/E1 Interface card w/ 128K NVRAM
- 881160 - Advanced Communication Server (ACS) with 68 logical Frame Relay ports
- 60500 - Host Firmware version 5.0.0 or above
- 62180 - ACS Frame Relay Server firmware

**Table 22—Frame Relay Server Specifications**

Input/Output Ports	68 logical ports (maximum)
Input Traffic Ports	T1, E1, fT1, fE1, V.35, RS422, EIA530, OCU-DP, FRAD
Output Traffic ports	T1, E1, fT1, fE1, V.35, RS422, EIA530, OCU-DP, FRAD
Output Port types/Input	UNI DCE, UNI DTE, NNI, Nx64K/56K FRAD
Maximum Frame Size	4K Bytes
Traffic Bandwidth	8 Mbps, Full Duplex
Performance	4,000 Frames per second (maximum)
Number of PVCs	128
System Capacity	Maximum 3 per IMACS
Management	RFC1315, DTE MIB, Frame Relay Service MIB, SNMP Alarm Traps per RFC 1215
Connectivity	Craft Interface, SNMP or TELNET
LMI Options	Q.933 Annex A, ANSI T1.617 Annex D, LMI (Gang of 4), None
Information Rates	CIR = 0 to 2048 Kbps, Bc = 0 to 2048 Kb, Be = 0 to 2048 Kb
Congestion Handling	FECN, BECN
Circuit Priorities	4 (Version 2.0 or above)

## Frame Relay Access and Concentration Server

This section highlights the capabilities of the IMACS Frame Relay server card as a cost-effective, efficient, and intelligent high-speed Frame Relay Assembly and Disassembly (FRAD) device and access concentrator in a Frame Relay network. This enables the service provider to deliver Frame Relay and Internet services with a high degree of quality in an economical fashion. The following is a list of the Zhone Technologies Frame Relay server card key benefits:

Highly efficient assembly, disassembly and concentration of Frame Relay traffic allows for significant Frame Relay switch port savings.

High Frame Relay port density offers significant hardware savings when compared to typical backbone switches making it suitable for deployment at the customer premises. Bringing the frame relay network features closer to the end-user and CO reduces backhaul charges due to efficient use of the frame relay backbone switch port.

100% compliance with industry Frame Relay standards enables ready interoperability in multi-vendor networks.

Support for existing UNI (User to Network Interface) and NNI (Network to Network Interface) standards implies that the frame relay server easily integrates into existing, standards-compliant frame relay infrastructure of the service provider.

- Manageability via SNMP and TELNET eliminates need for separate network management package and offers comprehensive diagnostics for both physical and logical network.
- Complete Support for physical layer diagnostics. In addition, it provides network access for a wide range of devices ranging from high-speed data interfaces (HSU), DDS interfaces (OCU-DP, DS0-DP), IDSL interfaces (BRI), and sub-rate data (FRAD).
- Comprehensive, standards-based congestion management techniques.

Standards based congestion management ensure interoperability with existing infrastructure and enables the service provider to offer better, more cost-effective Frame Relay services to its subscribers.

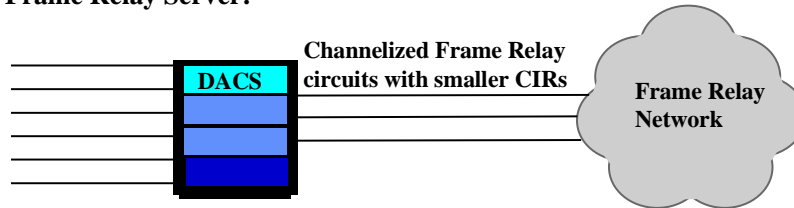
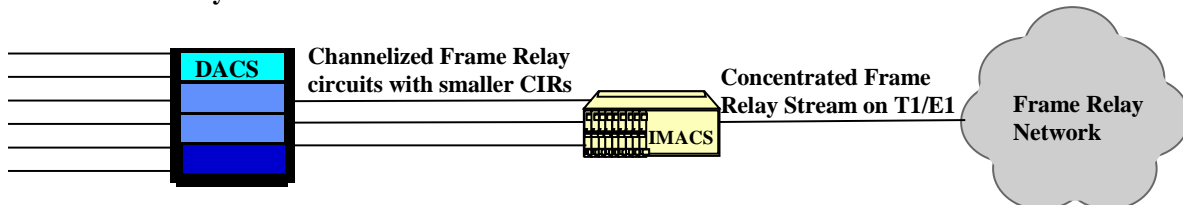
The Frame Relay Server can be deployed in the following application scenarios to provide a very cost-efficient and high-quality Frame Relay access to the end-users:

- Frame relay switch port savings
- Frame relay and Internet service provisioning
- IDSL service provisioning
- Grooming and concentration in cellular networks
- Central Office FRAD
- Frame relay concentration at hub sites

## Frame Relay Switch Port Savings

Figure 32 shows an IMACS equipped with one or more Frame Relay server cards that is utilized at the service provider's Central Office to efficiently concentrate multiple lower speed Frame Relay circuits into a consolidated Frame Relay stream into the backbone Frame Relay switch. This results in significant savings in port occupancy on the Frame Relay switch. It is amplified by the fact that these channelized ports on the backbone switches are much more expensive than their unchannelized counterparts.

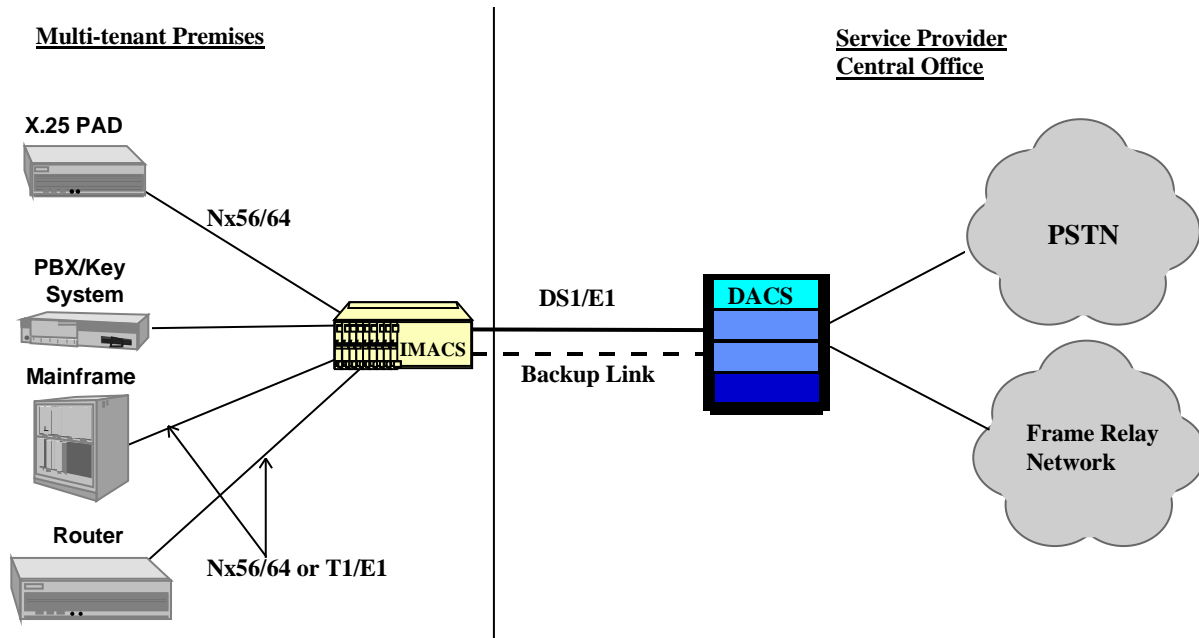
The presence of 68 highly-integrated channelized Frame Relay ports combined with the statistical multiplexing advantages of Frame Relay facilitate the savings by reducing the backbone switch port occupancy by over 2.5 times (67 DS0 circuits instead of 24 DS0 circuits on a single channelized T1 trunk). In a typical case this reduces circuit cost per DS0 by 20%.

**Without Frame Relay Server:****With Frame Relay Server:****Figure 32—IMACS Using Frame Relay Server Cards****Frame Relay and Internet Service Provisioning**

The inherent flexibility of the IMACS platform and the versatility of the Frame Relay server are brought into synergy to provide significant savings to both the service provider and user. An IMACS is used as a CLE (Customer Located Equipment) to provide a wide-variety of voice and data services to a multi-tenant premise. The service provider can now add Internet services and native Frame Relay services by simply installing a Frame Relay server in the existing IMACS as shown in Figure 33. There is no significant addition of new hardware or replacing of existing platform or complicated provisioning schemes. The Frame Relay Server also provides a PVC backup feature, which the service provider can offer as a premium, uninterrupted service to a customer in case the primary link fails.

The cost benefits are realized by the service provider as a result of:

- The high density of logical Nx56/64K ports on the Frame relay server enables very efficient grooming and concentration of Nx56/64K Frame Relay connections to the service provider access links.
- Savings in capital expenditure due to minimal hardware upgrades and ease of provisioning. In addition, the remote management capabilities of the IMACS and Frame Relay server improve the quality of service delivered thereby lowering costs.



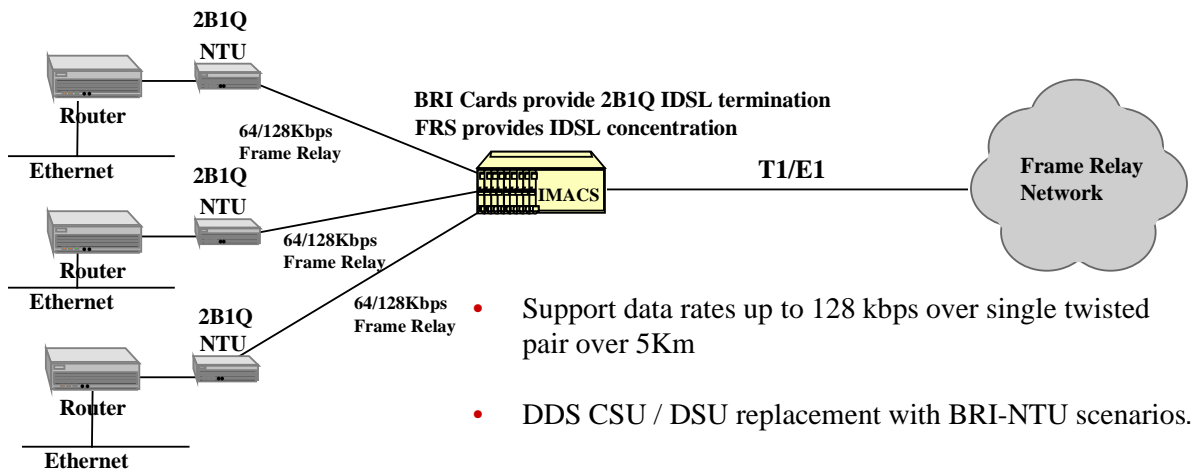
**Figure 33—Frame Relay and Internet Services Using IMACS' FRAD Server**

### **ISDL Service Provisioning**

An IMACS with a Frame Relay server can be used for efficient ISDN DSL (ISDL) provisioning for Internet access at speeds up to 128K. Each IMACS BRI card provides up to eight ISDL ports over single twisted pair wire. There can be up to seven such BRI cards in an IMACS800/900. This arrangement cost-effectively replaces external DDS CSU/DSU equipment and offers higher bandwidth.

Each Frame Relay server supports up to 35 NTUs at 128K over 1 T1 (with 3:1 concentration) or 1 E1 (with 2.5:1 concentration), thereby taking advantage of frame relay's statistical multiplexing capabilities. Up to 64 DS0s are channelized through the Frame Relay Server ports and are concentrated onto a single port connected to the network. Three concentrator ports bring in additional NXDS0s channels to be concentrated onto the single outgoing port as shown in Figure 34.

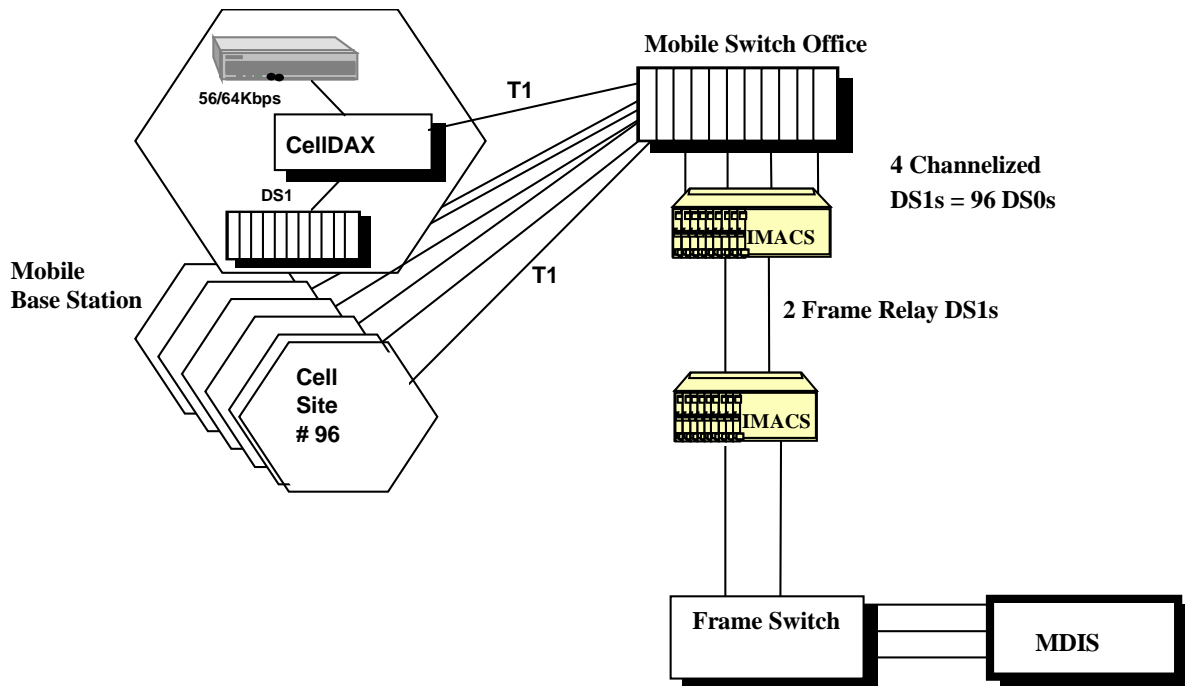




**Figure 34—IDSL Service Provisioning**

### Grooming and Concentration in Cellular Networks

Figure 35 shows how a remote cell site uses an IMACS, trademarked “CellDAX” for all cellular environments, to transport cellular voice and data traffic to the Mobile Switch Center (MSC). At the MSC, a DCS directs the CDPD traffic (typically, a single DS0) from each of the 96 cell sites to the IMACS at same MCS. Because CDPD uses HDLC framing the traffic from the 96 DS0s can be encapsulated by the two Frame Relay server cards located in the IMACS. Each Frame Relay server can take in 64 DS0s directly into ports. Typically the CDPD traffic is bursty and often less than one full DS0 and so can be groomed and concentrated by the Frame Relay server down to 48 or 24 DS0s depending upon the level of concentration needed. This results in a net savings of two or three T1/E1 spans across the regional MSCs respectively. The MD-IS (Mobile Data Intermediate System) then processes the traffic and routes it to the appropriate destinations.

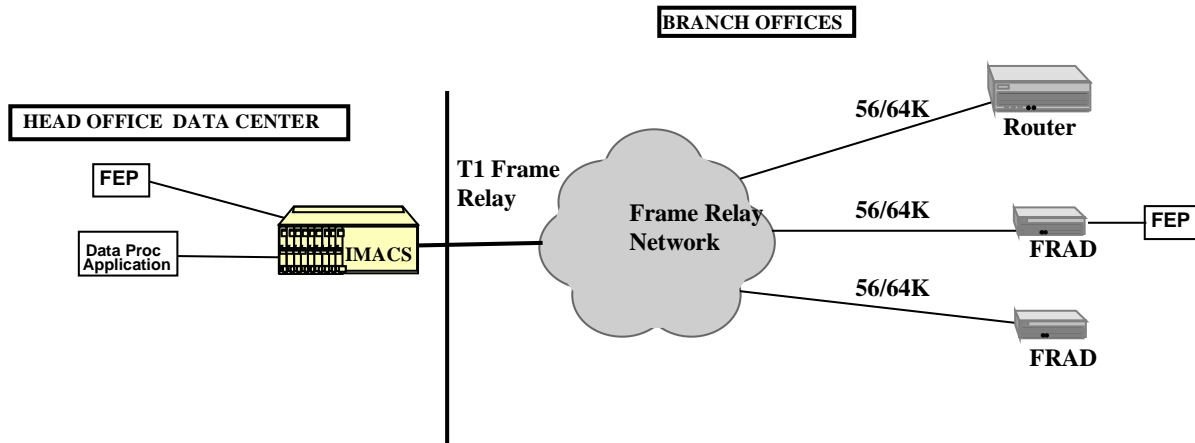


**Figure 35—Cellular Network Frame Relay Application**

### Frame Relay Concentration at Hub Sites

In the application shown in Figure 36, a corporation, which serves a wide geographical area through multiple branch offices, is able to utilize the Frame Relay server's ability to consolidate and multiplex multiple NX56/64K circuits into a single high-speed facility. This significantly reduces its access charges from its service provider for its corporate Frame Relay network. Typical examples include banks, health care providers, technology parks, etc.

The branch offices typically subscribe to a Frame Relay service with a Committed Information Rate (CIR) of 56/64K. At the Head Office/Data Center the traffic is typically from a "farm" of front-end processors, routers and servers. Without an IMACS+FRS at the Head Office/Data Center, multiple circuits would occupy multiple ports in the service provider's switch and would be tarified for lower individual speeds. With an IMACS+FRS, the multiple lower speed circuits are consolidated and groomed into a single/few high-speed (Nx64K) circuit. Since the marginal access charge of Frame Relay is lower at higher speeds, due to economies of scale, this could reduce costs.



**Figure 36—Frame Relay Concentration at Corporate Headquarters**

## 5. ATM SERVER CARD

Although ATM is being touted as an ubiquitous technology for all business communications services, the reality is that it is playing a significant role so far only in backbone campus network for LAN applications for local transport. This section highlights the benefits of the various applications of the IMACS 882060 ATM Server card and demonstrates how it can effectively and efficiently to deploy various services. The ATM Server Card provides the ability to provision legacy voice, data, and video services over an ATM backbone via a DS3, multi-mode and single-mode.

The ATM Server card includes support for efficient, standards-based ATM adaptation of a multitude of legacy traffic types. Examples include analog key systems, routers, video codecs and PBXs. Legacy traffic is directed from T1, E1, data and voice interfaces to the ATM Server, which then provide ATM adaptation and encapsulation. By providing direct, integrated connectivity to the ATM network, the IMACS eliminates the need to run parallel networks for ATM and TDM traffic. The ATM Server Card is based on standards adopted by the ATM Forum and the ITU. These standards allow the IMACS ATM Server to inter-operate with a wide variety of ATM switches and to adapt multiple traffic types for aggregation and transmission across an ATM network. Some of the well-known switches include those from FORE, Lucent, NORTEL, GDC, ADC Kentrox.

Since the ATM Server Card fits in any IMACS server slot, service providers can deploy the IMACS in non-ATM access networks today, and easily migrate to ATM based access by simply adding an ATM Server Card. The ATM Server Card, combined with the wide range of interfaces on the IMACS, provides the most flexible platform for service provisioning in the market today.

The following is a list of the ATM server card key benefits:

- Standards-based ATM adaptation for voice, video, and data. This feature enables the IMACS to adapt the traffic from a wide variety of legacy interfaces to ATM. Therefore there is no need to upgrade or replace existing equipment while migrating to ATM solutions. This results in significant savings in capital expenditure.
- Interoperable with deployed ATM switching equipment such as ADC Kentrox, Fore Systems, Lucent, etc. This is a key selling point of the ATM server. Because of its interoperability with already deployed ATM switching

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equipment, it can be easily added with minimal costs when the MIS manager wants to collapse parallel ATM and TDM networks into a single ATM network. When an ATM network is installed, typically there is excess bandwidth and port capacity that behooves such a merger of networks. For instance, when an ATM switch is deployed each line card will have multiple ATM ports out of which only one or two may be used for data traffic. The IMACS w/ ATM server can be connected to the unused port(s) thereby consolidating other legacy traffic on to the ATM network. This results in significant cost savings for the customer since there is only one as opposed to two networks to be managed.

- Provides DSO granularity for virtual circuit input. By providing DSO granularity, the ATM server is able to direct individual lower speed voice and data circuits to unique destinations through out the ATM network. This is accomplished without “burning up” multiple physical ports on the ATM switches, which are expensive. The ATM server’s highly efficient and cost-effective aggregation of lower speed CBR and VBR virtual circuits makes this possible.
- Supports constant and variable bit rate adaptation. By supporting constant and variable bit rate services, the ATM server tailors the adaptation to best suit application requirements for quality of service (QoS). E.g., typically voice and video applications require constant guaranteed bandwidth and stringent delay constraint and are modeled as CBR traffic. Data, compressed voice and compressed video are amenable to variations in bandwidth and delay requirements and are modeled as VBR traffic.
- Manageability via SNMP and TELNET. SNMP and TELNET manageability eliminates need for a separate IMACS network management package. The IMACS and its components can be managed from the same existing network management device that manages the ATM backbone and other devices.

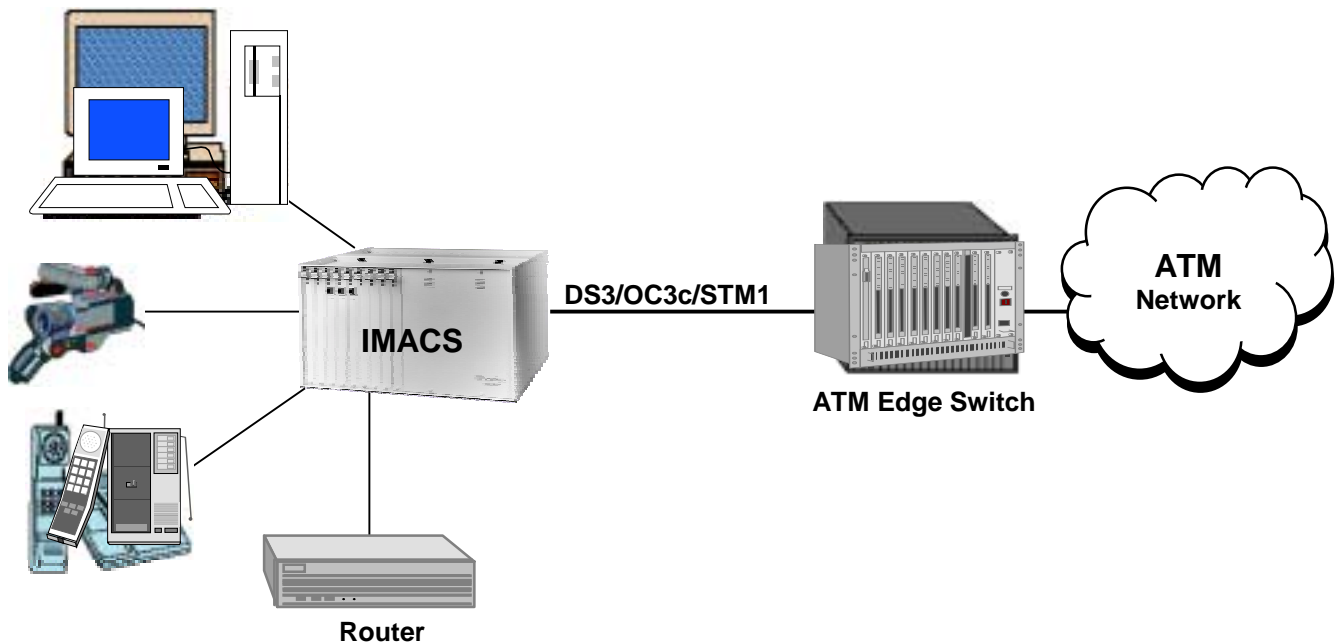
The ATM server is deployed in the following application scenarios to provide a very cost-efficient and high-quality ATM service to the end-users:

- Interactive Distance Learning/Tele-Medicine
- Legacy Adaptation to ATM
- Analog PBXs/Key Systems
- Digital PBXs
- Nx56K/64K Data terminal equipment
- Video Codecs
- Transparent LAN Extension

### **Legacy Adaptation to ATM**

The addition of the ATM Server card further extends the capabilities of the IMACS as a truly integrated access platform by efficiently provisioning a multitude of legacy services for transportation over an ATM network as shown in Figure 37.

There are still many legacy services (PBXs, key systems, video codecs etc.) which need a parallel TDM network to operate since they are not “ATM-ready.” Two parallel networks drive up the cost of installation, operation and maintenance. Since businesses have very significant capital investment in these legacy systems and processes they cannot justifiably be fork lifted and replaced by equivalent “ATM-ready” equipment. Furthermore, when a new ATM campus network is deployed, typically there is excess bandwidth and port capacity that is under utilized. What needs to be added is a cost-effective product for adaptation of all these legacy services to ATM. This would enable connecting a multitude of “non-ATM ready” equipment to the ATM network.



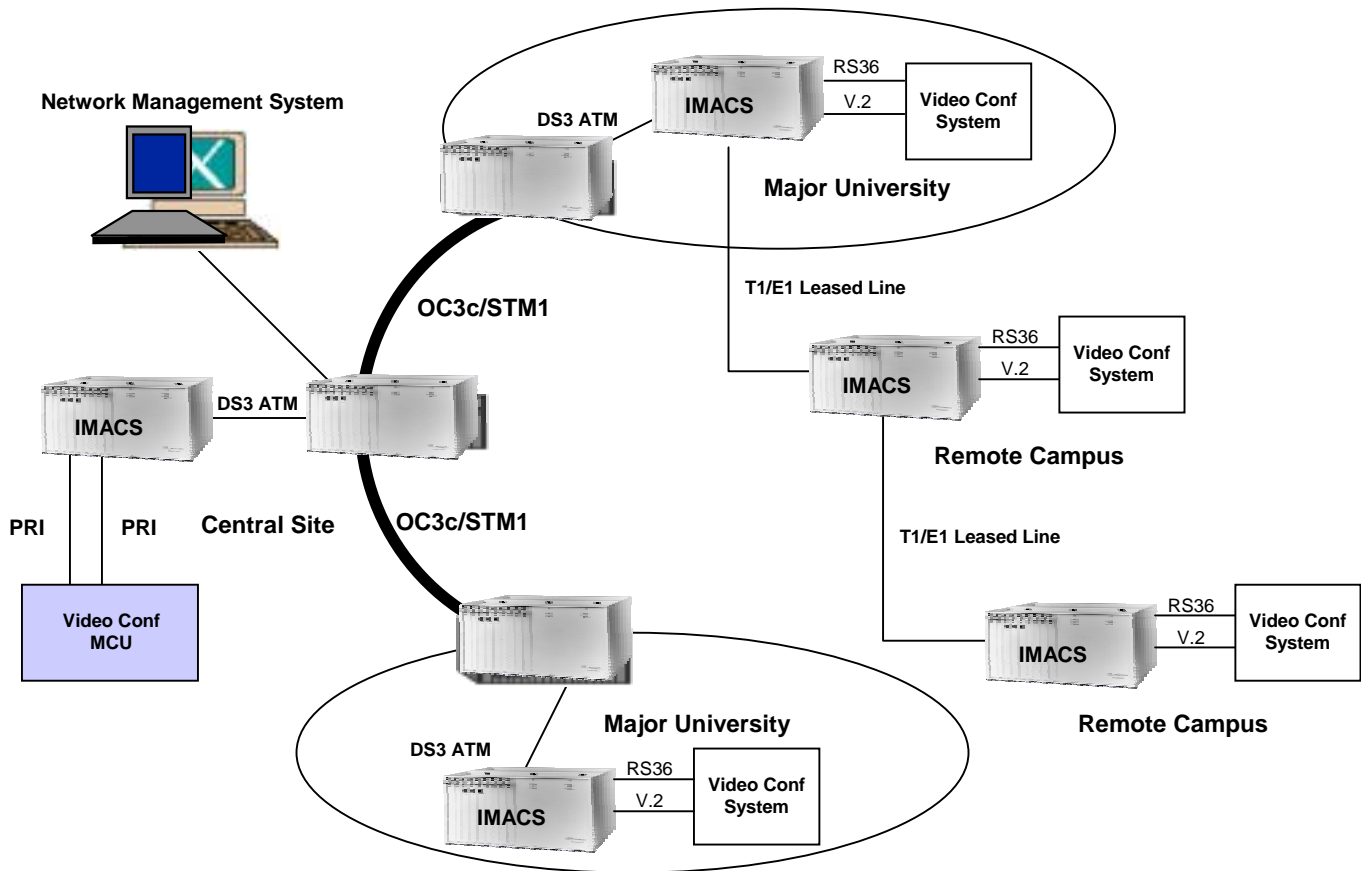
**Figure 37—Migrating Legacy Networks to ATM**

#### **Interactive Distance Learning/Tele-Medicine**

The IMACS' integrated multi-service capabilities supports interactive distance learning applications where the central site and the major educational centers are connected through an ATM network and the remote sites are accessed via leased T1/E1 lines.

The video stream (TDM traffic) from the central site is adapted to ATM by the ATM server and multi-cast to the sites on the ATM network as shown in Figure 38. The ATM servers located at the Major University locations convert the video from ATM to TDM traffic and pass it on to remote sites over leased T1/E1. The IMACS' ISDN PRI server is utilized in conjunction to connect the remote sites to the video-conferencing network over T1/E1 leased lines. The entire network is managed from a central network management system.

The same network structure is deployed effectively in a Tele Medicine application in which doctors from central medical centers can exchange patient information, X-rays etc. with remote hospitals and provide remote diagnosis.



**Figure 38—Interactive Distance Learning Application**

### ATM Server Specifications

Up to three ATM server cards can be functional in an IMACS in a non-redundant configuration. The ATM Server card performance figure of 4000 Frames/Second was obtained using 64 byte frames. Table 23 depicts the ATM Server card specifications. The following hardware and firmware must be included in an IMACS to add ATM Server operation:

- 880360- CPU Control Card with 8 T1/E1 Cross Connect (redundant-capable)
- 892360/892460 - 8 T1/E1 Interface card w/ 128K NVRAM
- 882060- ATM Server card with 1 DS3 ATM UNI port
- 60511 - Host Firmware version 5.1.1

**Table 23—ATM Server Card Specifications**

ATM I/F	1 DS3 Private UNI 3.1
Framing	Cbit, M23 for DS3
Cell Delineation	HCS (+ PLCP for DS3)
Clocking	Line (+PLCP for DS3)
VPI Support	One configurable VPI bit
VCI Support	33 - 1023 (configurable) values
Idle Cell	Idle or Unassigned
TX_RX Scrambling	ON/OFF
Traffic Types	CBR, VBR
AALs	AAL1, AAL3/4, AAL5
Number of PVCs	68 VBR, 96 CBR (with multi-user support)
Performance	4,000 FPS @ 64bits/frame
System Capacity	Maximum 3 per IMACS (1 active)
Management	DS3 MIB, UNI3.1 ILMI MIB, ATM MIB
Connectivity	SNMP or TELNET; Access via up to seven (7) Management PVCs
Standards	ATM Forum UNI3.0, ITU-T I.363, ITU-T G.709, BellCore TR-NWT-000253, ATM Forum Circuit-Emulation Services over DS1/E1, ATM Forum Service Interoperability

## 6. Internet Protocol Router

### Internet Protocol Router: 883060 (10Base2) and 883160 (10BaseT)

#### Introduction:

IPR is an IP router server card that runs on the ACS hardware. It therefore must be inserted in one of the P slots of the Zhone Technologies IMACS concentrator. IPR uses 68360 communication controller and has 4 MB of DRAM. To use the IPR card, one must use host version 5.0. The IPR has 4 interfaces: 1 Ethernet 10Base-T or 10Base-2 LAN interface and 3 Frame Relay WAN interfaces (ports). Ethernet interface supports 10Mbps/sec and 3 Frame Relay interfaces together support 2 \* T1/E1 access speed. IPR card has no Munich ports. Frame Relay ports can be connected through HSU or WAN cards. IPR is an IP router. This means that IPR forwards (routes) packets based on IP destination address, as opposed to FRS, that forwards packets based on a Frame Relay data link (dlci) address.

IPR routes IP datagrams (packets) between Ethernet and Frame Relay PVCs. Frame Relay PVCs can be associated with any of the 3 Frame Relay ports. (use of Ethernet is not mandatory, IPR can easily route just between Frame Relay PVCs). The maximum number of PVCs supported is 128. IPR also has provisions to automatically forward IP packets to and from the host (CPU) IP node of the IMACS box that IPR resides in. It automatically takes care of all the IP fragmentation to and from the host (CPU) IP node.

In addition to routing, IPR v2.0 is capable to bridge packets between Ethernet and Frame Relay bridge PVCs, and between Frame Relay bridge PVCs. IPR will forward packets matching an entry in the MAC addresses table, configured manually by the user. LAN broadcasts are being forwarded to all bridge PVCs. Because no spanning tree or learning algorithm is supported and to avoid loops, there should be no more than one physical connection between the same nodes. The maximum number of MAC addresses supported is 9. The maximum number of bridge PVCs supported is 9. Bridging function is enabled on host version 5.1.

IPR(s) can also be (optionally) connected to FRS server card (on the same IMACS), giving the customer an option of concentrating Ethernet traffic in addition to other ports of concentration on the FRS card (this is called an EtherFrad mode). This connection is possible from IPR port C1 only and is subject to bus allocation conflicts due to hardware limitation of the ACS card.

#### Maximum Byte Size:

The maximum number of bytes that an IPR can handle in a single packet is 1528 bytes (this is regardless whether a packet arrives from Ethernet or Frame Relay interface).

#### SNMP Support:

IPR has SNMP support for MIB 2, as well as SNMP support for Zhone Technologies Private MIB. IPR has a testing/debugging “on-the-fly” support, which includes displaying Routing table, displaying and clearing ARP table, displaying and clearing IP statistics, displaying and clearing PVC statistics in 15 minutes intervals for the last 96 intervals, displaying and clearing frame relay port statistics in 15 minutes intervals for the last 96 intervals, displaying and clearing LMI statistics, displaying and clearing Ethernet statistics.

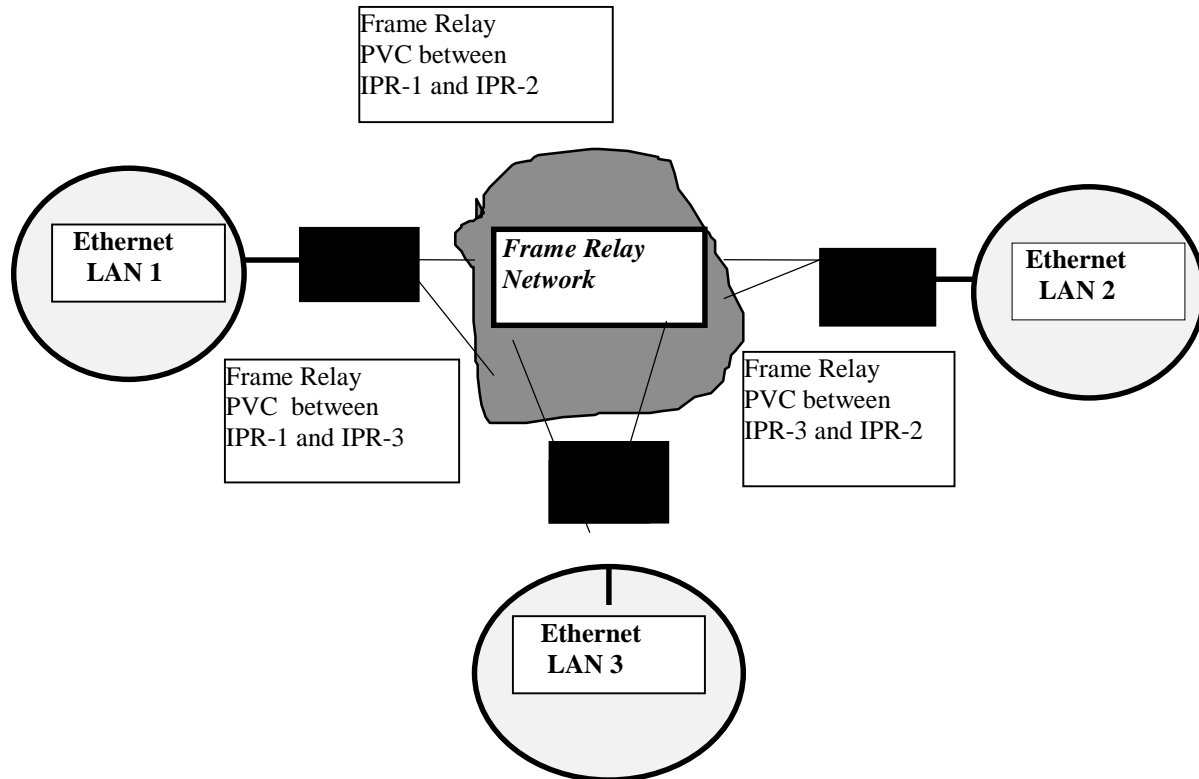
#### Standards Support:

- IPR uses a standard encapsulation of IP over Frame Relay (RFC 1490).
- IPR supports RIP (Routing Information Protocol, RFC 1058) for dynamically discovering IP routes from the adjacent IP routers on Frame Relay or Ethernet. IPR also supports static routes.
- IPR supports a DCE side of the Inverse ARP Protocol (RFC 1293).
- IPR can use different LMI encapsulations: ANSI, CCITT or LMI (Gang of Four). Each Frame Relay Port can be configured as either U-DTE, U-DCE, or NNI type.
- IPR supports Motorola LAPD packet forwarding protocol.



**Uses of IPR:**

- IPR can be used for connecting IP LANs together through Frame Relay network.
- IPR card can be used as a gateway to the Internet through Frame Relay network.
- IPR card can be used for connecting IP nodes on Ethernet to the IP nodes on Frame Relay network.

**Application:**

Note: Frame Relay PVCs can be associated with the same or with different Frame Relay ports.

**Routing Server**

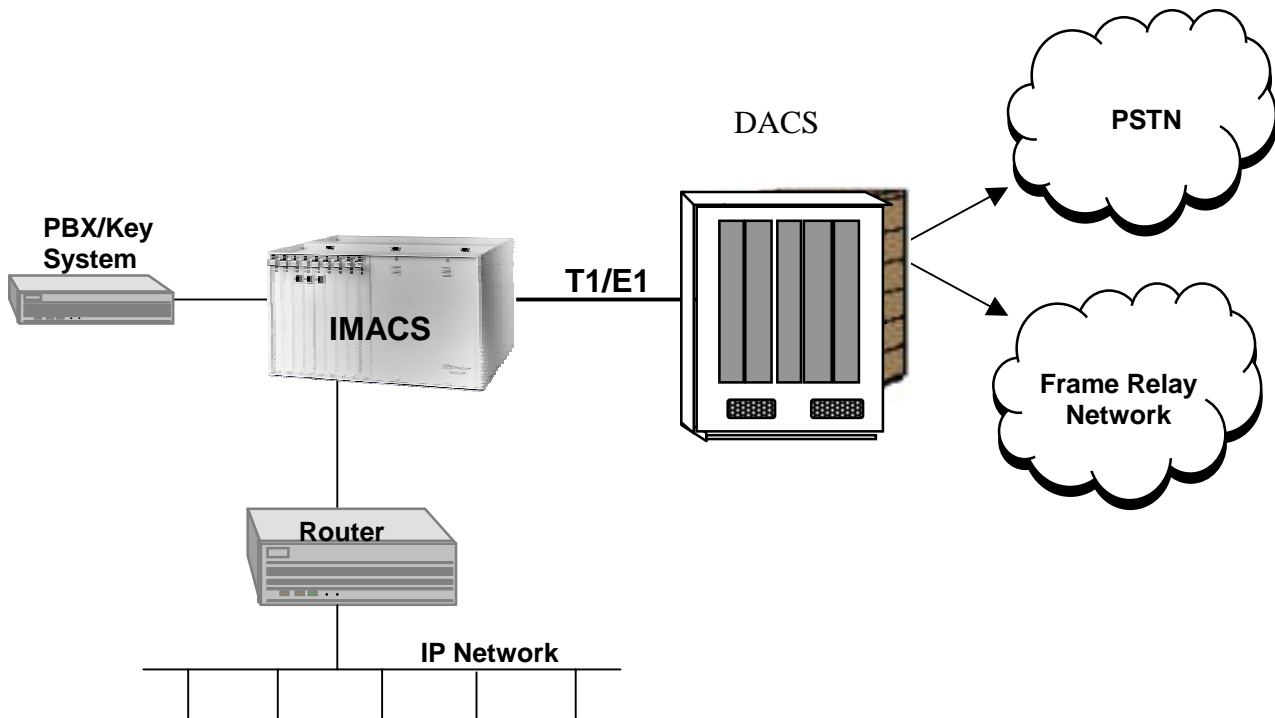
The IP Routing Server enables the IMACS to act as a gateway router to the Internet via bundled service deployment or in private Intranet network deployment. Specifically, the primary market for the IP Routing Server is Internet access via bundled service arrangements (integrated access). The bundled service marketplace is simply the provisioning of multiple services over a single T1 or E1 to a customer. Typical bundled service arrangements include local voice service, long distance service and a data service. Internet access is one of the possible data services. The potential market for this technology is quite extensive. There are over 6.5 million small businesses in the US, and about 1.3 million of these have 6 to 20 phone lines. These businesses are prime candidates for bundled service arrangements.

The IMACS platform is unique in that it possesses many of the qualities listed below in a flexible form factor. The addition of layer-3 (IP) data services to the product portfolio will further distance Zhone Technologies from the competition. As equipment and technologies mature, there is a constant requirement to consolidate communications equipment for many reasons, including:

- Lower capital costs
- Integrated management
- Ease of use and installation
- Remote connection efficiency

### Bundled Service Deployment

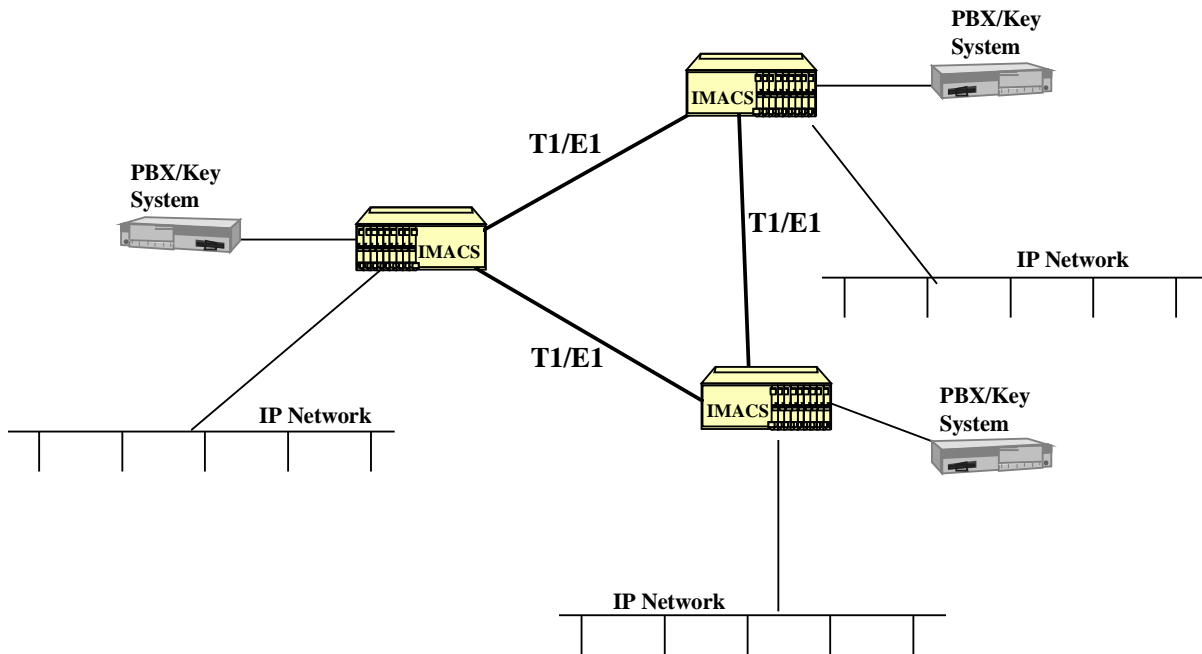
The IP Routing Server is targeted at performing boundary routing functions for access to Internet or Intranet based services. The standard application for an IMACS in this environment is in bundled service arrangements where the IMACS is utilized to integrate voice circuits and an Ethernet-based Internet port at the customer location as shown in Figure 39. The carrier would typically switch the voice circuits to the PSTN via a DACS, while the frame relay-based data connection from the Ethernet port would be connected to a Frame Relay network for transmission to the Internet. An external firewall can be used for providing and maintaining security when connected to the Internet.



**Figure 39 – IP Routing Server For Internet or Intranet Based Services**

### Private Intranet Deployment

A secondary market for the IP Routing Server is private Intranet access. In the application shown in Figure 40, the IMACS on the left is connected to a private WAN. It has a single connection to a centralized router, which provides full IP routing functionality. The IMACS on the right has two T1 connections, one to each of the two remote IMACS, and one connection to the router. Normally, there would be two connections to the router. However, in this application, the IMACS on the right includes a Frame Relay Server card, which switches both frame relay streams into the router.



**Figure 40—Private Intranet Deployment Using IP Routing Server Card**

### IP Routing Server Specifications

Up to three IP Routing server cards can be functional in an IMACS in a non-redundant configuration. The processor performance figure of 3500 packets/second was obtained using 64 byte packets. Table 24 describes the IP Routing Server card specifications. The following hardware and firmware must be included in an IMACS to add IP Server operation:

- 880360 - CPU Control Card with 8 T1/E1 Cross Connect (redundant-capable)
- 892360/892460 - 8 T1/E1 Interface card w/ 128K NVRAM
- 883060 - Advanced Communications Server (ACS) with 10Base2 card
- 883160 - ACS with 10BaseT card
- 60511 - Host Firmware version 5.1.x
- 67200 - IP Routing Server firmware

**Table 24—IP Routing Server Card Specifications**

Input/Output	4 maximum (1 10-BaseT Ethernet, 3 Frame Relay Wide-Area Network)
LAN Traffic I/O	10BaseT, 10Base2
Frame Relay Traffic I/O	T1, E1, fT1, fE1, V.35, RS422, EIA530
Frame Relay Port types	UNI DCE, UNI DTE, NNI
MTU	1500 bytes
Traffic Bandwidth	4Mbps Full Duplex
Total Buffer Space	4 Mb DRAM
Performance	3500 Packets Per Second
No of PVCs	128
Routing Table	512 entries (up to 128 static entries)
ARP Table	100 entries (LRU)
Card Capacity	Maximum 3 per IMACS
Management	RFC 1315 DTE MIB, Frame Relay Service MIB, SNMP Alarm Traps per RFC 1215
Connectivity	SNMP or TELNET
LMI Options	Q.933 Annex A, ANSI T1.617 Annex D, LMI (Gang of 4), None
Information Rates	CIR = 0 to 2048 Kb/s, Bc = 0 to 2048 Kb, Be = 0 to 2048 Kb
Congestion Handling	FECN, BECN
DCE Parameters	N392, T391, N393 all configurable
DTE Parameters	N392, T391, N393, N391 all configurable
IP subnet Topologies	Point-to-point, hub-and-spoke, fully/ partially meshed subnets, and unnumbered IP interfaces.

## 7. Low-Bit Rate Voice Server

The **LBRV (Low Bit Rate Voice)** Server card allows for the compression of 64Kbps digital voice channels into 8Kbps (plus overhead) digital sub-channels, and subsequently for the sub-channels to be multiplexed over one, two or three composite transmission paths over Wide Area Network (WAN) links. The LBRV Server can accept voice inputs from either analog voice ports (such as FXS, FXO, E&M) or from T1/E1 WAN links through the IMACS.

Each LBRV / ACELP (G.729) voice compression server card supports up to three composite transmission paths at speeds of 64k, 128k or 192k, by using one, two or three WAN time slots, respectively. The composite transmission paths use HDLC protocol as the transport mechanism. Users assign voice channels to one, two or three transmission paths based on the need to route those channels through the network. The composite transmission paths can be routed directly to WAN cards or to the Frame Relay Server. When routed to a Frame Relay Server (FRS), the FRS provides a FRAD function for the compressed voice frames. No Frame Relay sub-addressing is supported, so all voice channels within each composite transmission paths from the ACELP will be treated as a single PVC.

There are two models of the LBRV server cards: 830060 (8 port) and 831060 (16 port) capacities. A single IMACS chassis we can support up to 3 LBRV cards for compression of a maximum of 48 voice ports.

The LBRV card performs DTMF recognition and re-construction. This means the integrity of DTMF does not suffer from the compression/decompression processes. The LBRV card does not support MF signaling between switches. The following is a list of the Zhone Technologies LBRV key benefits:

- Simple topologies including Point-to-Point, Star and Mesh LBRV performs a compression and transport function. It does NOT perform voice switching and call routing.
- High density of channels and high volume of traffic.
- LBRV solution is competitive with high volumes of traffic. There should be many (24+) voice channels in one location.
- High reliability in mission-critical installations.

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IMACS with LBRV is suited to carrier networks and service organizations where downtime is unacceptable. Examples include call centers; help desks, and inter-exchange trunks. IMACS with LBRV offers high reliability through:

- Hardware redundancy
  - Environmental ruggedness
  - No moving parts
  - Path redundancy (with FRS). It can be achieved through Backup PVC feature, which switches to an alternate path upon either Loss of LMI [loss of FR administration connection or WAN CGA alarm (T1/E1 failure)]
- Carrier networks requiring specialized Telco interfaces.

IMACS has specialized Telco interfaces found in carrier environments such as :

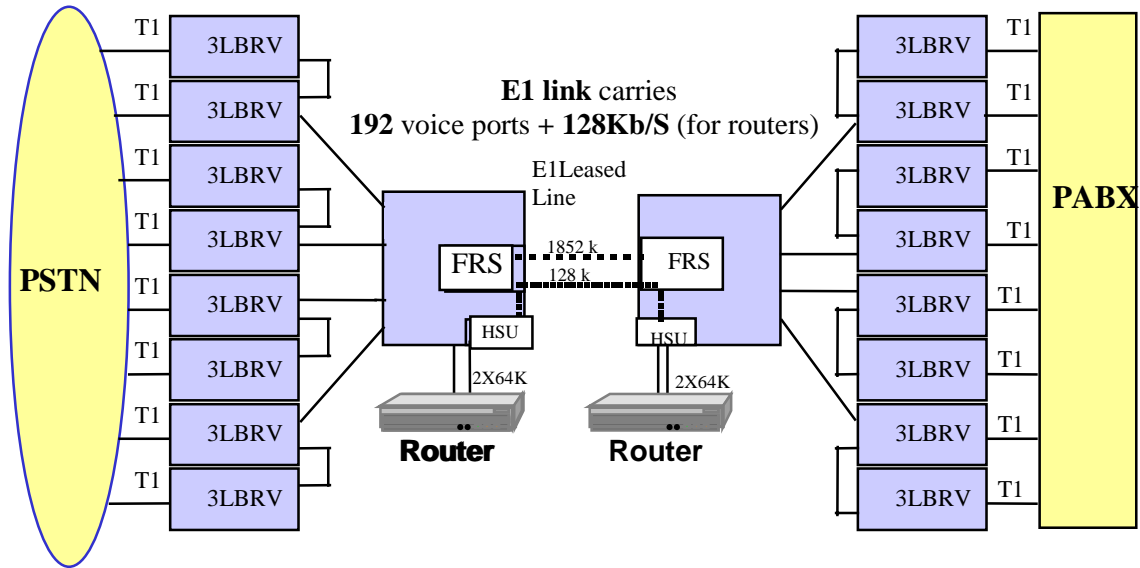
- Coin phone (12/16 kHz or battery reversal)
- 64 kbps G.703 co- / contra-directional
- BRI & PRI ISDN voice
- T1 and E1 interface

The IMACS equipped with the LBRV Server card offers cost-effective applications including:

- Bulk voice compression for remote call center
- Back-hauling voice for new carriers (e.g. centralized voice mail)
- Extending voice access network over VSAT

### **Call Center Application**

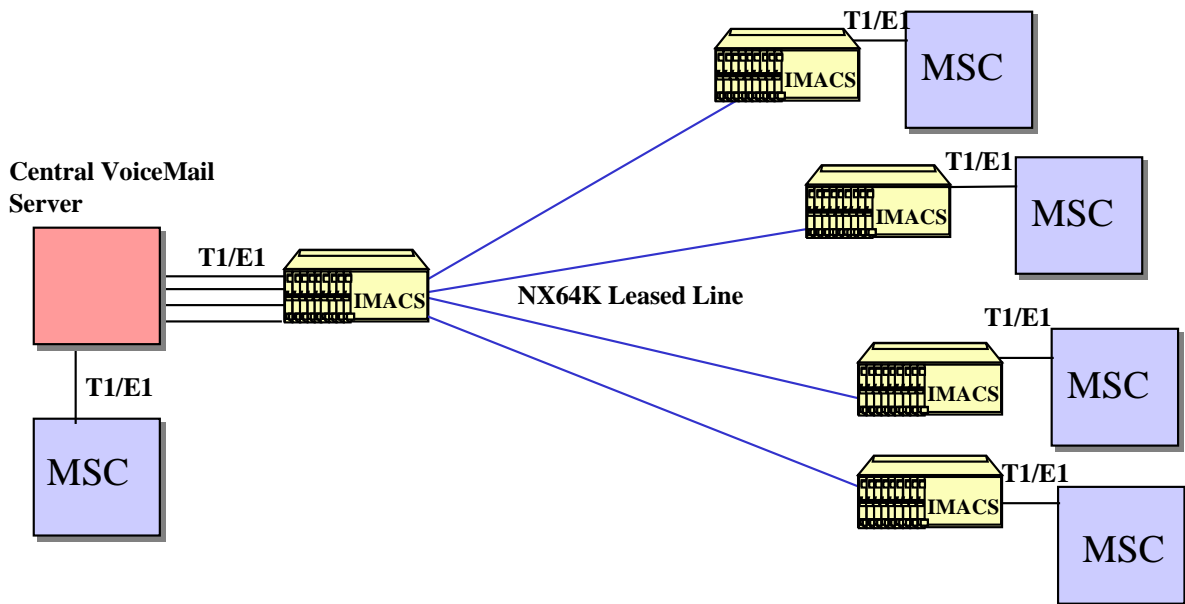
In the application shown in Figure 41, customer calls originating from the PSTN, are compressed by the LBRV server for efficient transmission on the leased E1 trunk, using frame relay. Up to three LBRV servers are used per up to 8 IMACS terminals to compress up to 192 voice channels from the PSTN. Groups of two IMACS terminals are combined. The first IMACS terminal of each pair uses 3 128 Kb/S channels each carrying 8 compressed voice sub-channels (9.646 Kb/S per channel), effectively using only 77.16 Kb/S out of 128 Kb/S. The 3 channels are inserted into the second IMACS terminal over a local T1 link. The second IMACS terminal combines its 3 128Kb/S channels and the other 3 128 Kb/S channels into a single T1 link feeding into another IMACS terminal equipped with the Frame Relay server. Ultimately, 4 T1 links bring the compressed voice signal from all 192 PSTN ports to the frame relay IMACS. Although the total occupied bandwidth on all 4 T1 links is 3073 Kb/S (6 x 4 x 128 Kb/S) the effective bandwidth used is only about 1852 Kb/S (4 x 2 x 3 x 8 x 9.646). The Frame Relay server takes the advantage of this and combines only the effective bandwidth over an E1 unstructured transmission link. This still leaves 128 Kb/S of the total E1 bandwidth (1984 Kb/S) for data traffic from a router attached to the IMACS terminal via an HSU card. The Frame Relay server IMACS is used at the hub locations to send voice and data traffic on a single leased E1 trunk.



**Figure 41—LBRV In a Call Center Application**

**Backhauling Voice Application**

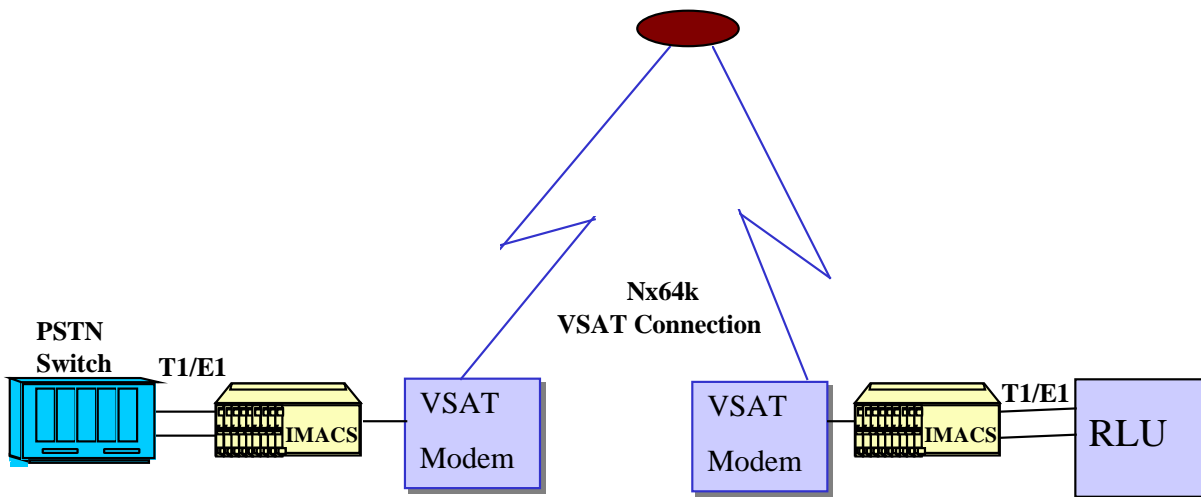
The IMACS equipped with an LBRV server, can be used by new wireless carriers, who need to lease Telco facilities between their geographically separate Mobile Switching Centers (MSC). They can use the LBRV server shown in Figure 42 to use the leased link very efficiently thereby reducing hauling costs.



**Figure 42—Backhauling Voice Application**

**Extending Voice Access Application**

The application shown in Figure 43 is similar to the previous one where the LBRV is deployed to utilize the lower-speed but expensive VSAT link very efficiently.



**Figure 43—LBRV Voice Access Application**

## VII. IMACS System Testing and Diagnostics

### IMACS System Parameters

System level parameters that are supported include a user-defined node name called the node ID. It can be up to 14 alphanumeric characters long without spaces and four password-protected access levels that correspond to different access and capability levels. Additionally, the IMACS allows users to customize alarm management functions to their requirements.

### Password Protection

The four access levels that are available to users are: “super-user,” “manager,” “operator,” and “viewer”. The highest is “super user” which allows flash download of software, full access to all configuration options, diagnostic features, and password management. The “operator” access level allows read and write access to all configuration and diagnostic functions and the “viewer” access level, which is the lowest, allows read-only access to system status and configuration options.

All four access levels are protected by user-defined passwords. Passwords can be up to 12 alphanumeric characters and are case-sensitive. The ability to change passwords is hierarchical in that someone logging in at a certain access level may change the passwords associated with their own level and the passwords associated with lower access levels. For example, “super user” may change the passwords associated with all four levels. Similarly, “operator” may change the password associated with both the “operator” and the “viewer” levels only.

### Port Status Summary

The IMACS supports the ability to display a summary of the status of each port on every card installed in the system. This information is displayed in the main menu screen next to the card type field associated with each slot. The user has the option of turning this information on or off with a single keystroke by pressing the “s” key. All loop backs that are commanded from the user interface will be represented on the main screen. In addition to the Out-Of-Service (OOS) and Reject (REJ) messages that are associated with the status of the entire card, the system will describe the status of each port by displaying one of the following letters:

<u>Letter</u>	<u>Meaning</u>
“a”	Port is active
“s”	Port is in standby mode
“l”	Port is in loop back
“t”	Port is in test mode
“r”	Port is the redundant mate of an active port (Applies to WAN ports and ADPCM card)



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## IMACS Diagnostic Capabilities

### Status and Alarm Management

The IMACS supports a comprehensive alarm message generation and reporting capability that provides the system operator with a complete view of the operation of the system. Alarm messages that are supported include, Out-Of-Service (OOS) condition (any card, module, power supply or ringing generator that fails or is removed from the system), No Signal (NOS), Loss of Synchronization (LOS), AIS alarm, CGA-Red alarm, CGA-Yellow alarm, Excessive Error Rate (EER), Alarm card sensor (SENSOR), D-channel out of service (DCHAN), Switch to redundant card (SWITCH), User card/port alarm (UCA), System reset (RESET), Alarm Cut-Off (ACO), Clock Sync alarm (SYNC), Error rate above 10e-3 (EER-3), DS3 PCLP Out of Framing (PLC\_OOF), DS3 PCLP Loss of Frame (PLC\_LOF) and DS3 PCLP Yellow alarm (PLC\_YEL).

The IMACS supports the setting of filters for each alarm message that is generated by the system. These three filters define the manner in which the alarm will be reported and take precedence over the designation of the level of the alarm.

- Setting the filter of a specific alarm to “report” will cause the system to display the alarm message on the screen, log it into the alarm history file and report it to a remote device by dialing a pre-programmed telephone number through the built-in modem or by sending an SNMP trap via IP.
- Setting the filter to “log” will (a) display the alarm message on the screen and (b) log it into the alarm history file.
- Setting the filter to “ignore” will cause the alarm indication to be ignored by the system.

In addition to the three filters, each alarm may be designated as “info”, “major”, “minor” or “critical”. When used in conjunction with the Model 840X External Alarm card, the occurrence of any alarm designated as “major” will trigger a form-C contact on the External Alarm card, which in turn can serve to activate an external device such as a bell or light. Similarly, the occurrence of any alarm designated as “minor” would trigger a different contact and, therefore, activate a different external indicator.

The system supports a standard feature known as Alarm Cut-Off (ACO). If the ACO function is enabled, by setting it to “log” or “report”, then any major alarm that is set to “report” or “log” will automatically cause an ACO message to be generated. The ACO will not disappear until it is manually cleared by the operator.

This feature is useful in situations where an alarm condition occurs and then clears itself while the system is unattended. When the operator returns, there will be no indication on the console screen that anything had happened. However, if the ACO function is enabled, then the ACO message will remain on the screen thereby notifying the operator that certain events occurred while the node was unattended. The operator can then query the alarm history file for further information.

Alarms may be set to “report” in which case the IMACS will dial a remote device after a “wait” period. The user may define the wait period for both Major and Minor alarms. The wait period can be between 1 and 500 seconds for a Major alarm and between 1 and 32,000 seconds for a Minor alarm.

The user may specify in software the remote device’s telephone number, printout retry interval if the remote device is busy (1 minute to 60 minutes, in 1 minute intervals) and the maximum number of times (from 1 to 99) that the system will attempt to contact the remote device before giving up.

The user may customize the appearance of alarm messages by specifying the order that the six message elements should appear in. Those elements are: (1) slot position (“address”), (2) card type (“model”), (3) alarm type (“alarm”), and (4) start and stop time and date stamps (“time”), (5) alarm sequence number “number”, (6) alarm severity (“severity”).

### Integral Test Capabilities

The IMACS provides a comprehensive set of built-in diagnostic tools that enable the operator to remotely troubleshoot and resolve problems. In addition to the system-generated alarm messages described above, the

integral diagnostic capabilities of the IMACS include Bit Error Rate Testers (BERTs) on data cards, tone generators on analog voice cards, the ability to manipulate the analog leads and the digital signaling bits of voice circuits and extensive loop back generation and detection capability on many system elements.

The ability to initiate loop backs at various points in a circuit, coupled with the ability to generate and receive test signals and to collect performance and error information, enables the operator to systematically troubleshoot circuit problems. It allows the operator to determine if the problem resides in the IMACS system, and whether the problem can be isolated down to a specific Field Replaceable Unit (FRU) within the system. Since all of these diagnostic tools can be operated from a VT100 terminal, troubleshooting begins immediately without dispatching an on-site technician.

The diagnostic capabilities of the IMACS system are described in the following section. They are divided into four categories: (1) WAN diagnostics, (2) voice diagnostics, (3) data diagnostics and (4) cross-connect diagnostics.

### WAN Diagnostics

Software-initiated diagnostics on T1 and E1 WAN aggregates include looping the WAN signal toward the network (line loop back) or the IMACS system (local loop back) and placing any one of the DS0 channels that make up the WAN signal in local loop back. See Table 25 for a complete list of diagnostic capabilities.

**Table 25-- Diagnostic Capabilities of Single and Dual WAN Cards**

#### On-Card Loop backs

LOOP BACKS	T1/CSU	T1/DSX	E1/CEPT/HDSL
T1/E1 Line Loop back Toward Network	Yes	Yes	Yes
T1/E1 Local Loop back Toward User	Yes	Yes	Yes
DS0 Channel Loop back Toward Network	No	No	No
DS0 Channel Loop back Toward User	Yes	Yes	Yes

#### In-Band Loop back Code Generation

LOOP BACKS	T1/CSU	T1/DSX	E1/CEPT/HDSL
Industry-Standard T1/E1 Loop-Up Code	Yes	Yes	N/A
Industry-Standard T1/E1 Loop-Down Code	Yes	Yes	N/A

#### In-Band Loop back Code Detection

LOOP BACKS	T1/CSU	T1/DSX	E1/CEPT/HDSL
Industry-Standard T1/E1 Loop-Up Code	Yes	Yes	N/A
Industry Standard T1/E1 Loop-Down Code	Yes	Yes	N/A

#### Bit Error Rate Tester (BERT)

#### Patterns Supported

LOOP BACKS	T1/CSU	T1/DSX	E1/CEPT/HDSL
All 1s	Yes	Yes	Yes
All 0s	Yes	Yes	Yes
1:1	Yes	Yes	Yes
1:7	Yes	Yes	Yes
3:24	Yes	Yes	Yes
QRSS	Yes	Yes	Yes

**BERT Direction**

<b>LOOP BACKS</b>	<b>T1/CSU</b>	<b>T1/DSX</b>	<b>E1/CEPT/HDSL</b>
Toward Network	Yes	Yes	Yes

**Statistics Gathered By BERT**

<b>LOOP BACKS</b>	<b>T1/CSU</b>	<b>T1/DSX</b>	<b>E1/CEPT/HDSL</b>
Bit Errors (BE)	Yes	Yes	Yes
Errored Seconds (ES)	Yes	Yes	Yes
Severely Errored Seconds (SES)	Yes	Yes	Yes
Consecutive Severely Errored Seconds (CSES)	Yes	Yes	Yes
Out of Synchronization Seconds (OSS)	Yes	Yes	Yes
Bit Error Rate (BER)	Yes	Yes	Yes
Elapsed Seconds (ELAP)	Yes	Yes	Yes
HDSL Errored Seconds	N/A	N/A	Yes*
HDSL Severely Errored Seconds	N/A	N/A	Yes*
HDSL Unavailable Seconds	N/A	N/A	Yes*

\* applicable only for the E1-HDSL plug-in module. Also the same statistics are available for the remote end.

**Voice Diagnostics**

The software-initiated diagnostics supported on voice cards include the setting of both analog and digital loop backs toward the network and the generation of Quiet Tone and a Digital MilliWatt signal on a port-by-port basis. The operator can also monitor and set the state of the analog leads of any FXS, FXO or E&M port. They can set and monitor the state of the ABCD signaling bits of the digitized voice signal. In cross-connect systems, test functionality also includes the ability to generate test tones (300Hz, 1 kHz and 3 kHz) and transmit those toward the user side or the network side of the system. Refer to Table 26 for detailed information on the diagnostic capabilities of the voice cards.

**Table 26—Diagnostic Capabilities of Voice Ports**

	<b>2-wire E&amp;M</b>	<b>4-wire E&amp;M</b>	<b>4-wire Extended E&amp;M</b>	<b>2-wire FXS</b>	<b>2-wire FXO</b>
<b>LOOP BACKS</b>					
<u>On-Card Loop backs</u>					
Analog Toward Network	Yes	Yes	Yes	Yes	Yes
Digital Toward Network	Yes	Yes	Yes	Yes	Yes
<b>SIGNALING MANIPULATION</b>					
Set Status of Analog Interface Leads	Yes	Yes	Yes	Yes	Yes
Set Transmit ABCD Signaling Bits	Yes	Yes	Yes	Yes	Yes
Set Receive ABCD Signaling Bits	Yes*	Yes*	Yes*	Yes*	Yes*
Monitor Status of Analog Interface Leads	Yes	Yes	Yes	Yes	Yes
Monitor Status of Transmit ABCD Signaling Bits	Yes	Yes	Yes	Yes	Yes
Monitor Status of Receive ABCD Signaling Bits	Yes	Yes	Yes	Yes	Yes
<b>TONE GENERATION</b>					
<u>Tones Supported</u>					
300 Hz	Yes*	Yes*	Yes*	Yes*	Yes*
1 kHz	Yes*	Yes*	Yes*	Yes*	Yes*
3 kHz	Yes*	Yes*	Yes*	Yes*	Yes*

Quiet Tone	Yes	Yes	Yes	Yes	Yes
Digital MilliWatt	Yes	Yes	Yes	Yes	Yes
<u>Tone Direction</u>					
Toward User	Yes	Yes	Yes	Yes	Yes
Toward Network	Yes	Yes	Yes	Yes	Yes

- *This feature is only supported in Cross-Connect Systems*

### Data Diagnostics

Data diagnostics support varies among data cards. Refer to Table 27 for detailed information on data card diagnostics. Generally, data card diagnostics supported include the setting of various levels of loop backs toward the network or the attached DTE equipment. Other support includes the ability to generate and respond to industry-standard loop-up and loop-down codes that are compatible with DDS, V.54 and/or Fractional T1 (FT1) formats. The DS0-DP data card generates and detects DS0-DP loop back codes.

**Table 27—Diagnostic Capabilities of Data Ports**

	EIA530 HSU 2-port	V.35 HSU 2-port	EIA530/V.35 HSU 4-port	SRU	OCU-DP 2/5/10-port	DS0-DP 4-port
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### LOOP BACKS

#### On-Card Loop backs

	EIA530 HSU 2-port	V.35 HSU 2-port	EIA530/V.35 HSU 4-port	SRU	OCU-DP 2/5/10-port	DS0-DP 4-port
Toward DTE	Yes	Yes	Yes	Yes	Yes	Yes
Toward Network	Yes	Yes	Yes	Yes	Yes	Yes

#### In-Band Loop back Code Generation

	EIA530 HSU 2-port	V.35 HSU 2-port	EIA530/V.35 HSU 4-port	SRU	OCU-DP 2/5/10-port	DS0-DP 4-port
Latching DDS-OCU	Yes	Yes	Yes	Yes	Yes	Yes
Latching DDS-DSU	Yes	Yes	Yes	Yes	No	Yes
Latching DDS-CSU	Yes	Yes	Yes	Yes	Yes	Yes
Latching DDS-DS0	Yes	Yes	Yes	No	Yes	Yes
ITU (CCITT) V.54	Yes	Yes	Yes	No	No	No
ANSI Fractional T1 (FT1)	Yes	Yes	Yes	No	No	No

#### Control Lead Handling

	EIA530 HSU 2-port	V.35 HSU 2-port	EIA530/V.35 HSU 4-port	SRU	OCU-DP 2/5/10-port	DS0-DP 4-port
Set CTS	Yes	Yes	Yes	Yes	N/A	N/A
Set RLSD	Yes	Yes	Yes	Yes	N/A	N/A
Set DSR	Yes	Yes	Yes	No	N/A	N/A
Monitor RTS	Yes	Yes	Yes	Yes	N/A	N/A
Monitor DTR	Yes	Yes	Yes	No	N/A	N/A

**Bit Error Rate Tester (BERT)****Patterns Supported**

	<b>EIA530 HSU 2-port</b>	<b>V.35 HSU 2-port</b>	<b>EIA530/V.35 HSU 4-port</b>	<b>SRU</b>	<b>OCU-DP 2/5/10-port</b>	<b>DS0-DP 4-port</b>
All 1s	Yes	Yes	Yes	Yes	Yes	No
All 0s	Yes	Yes	Yes	Yes	Yes	No
1:1	Yes	Yes	Yes	Yes	Yes	No
1:7	Yes	Yes	Yes	Yes	Yes	No
511	Yes	Yes	Yes	Yes	Yes	No
2047	Yes	Yes	Yes	Yes	Yes	No
QRSS	Yes	Yes	Yes	Yes	Yes	No

**BERT Direction**

	<b>EIA530 HSU 2-port</b>	<b>V.35 HSU 2-port</b>	<b>EIA530/V.35 HSU 4-port</b>	<b>SRU</b>	<b>OCU-DP 2/5/10-port</b>	<b>DS0-DP 4-port</b>
Toward User	No	No	No	Yes	Yes	No
Toward Network	Yes	Yes	Yes	Yes	Yes	No

**Statistics Gathered by BERT**

	<b>EIA530 HSU 2-port</b>	<b>V.35 HSU 2-port</b>	<b>EIA530/V.35 HSU 4-port</b>	<b>SRU</b>	<b>OCU-DP 2/5/10-port</b>	<b>DS0-DP 4-port</b>
Bit Errors (BE)	Yes	Yes	Yes	Yes	Yes	No
Errored Seconds (ES)	Yes	Yes	Yes	Yes	Yes	No
Severely Errored Seconds (SES)	Yes	Yes	Yes	Yes	Yes	No
Consecutive Severely Errored Seconds (CSES)	Yes	Yes	Yes	Yes	Yes	No
Out of Synchronization Seconds (OSS)	Yes	Yes	Yes	Yes	Yes	No
Bit Error Rate (BER)	Yes	Yes	Yes	Yes	Yes	No
Elapsed Seconds (ELAP)	Yes	Yes	Yes	Yes	Yes	No

**Systems Equipped With Cross-Connect Option**

In systems equipped with Cross-Connect CPUs, the cross-connect element adds another level of testing within the node and enhances the system's diagnostic capabilities. The operator may also monitor and set the state of the Transmit and Receive ABCD signaling bits of a digitized voice circuit that is cross-connected between two WANs. Refer to Table 28 for detailed information.

**Table 28—Diagnostic Capabilities of Cross-Connect Circuits****Loop Backs****Local Loop backs**

	<b>Voice Without Signaling</b>	<b>Voice With Signaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
Toward WAN1	Yes	Yes	Yes	Yes
Toward WAN2	Yes	Yes	Yes	Yes

**Bit Error Rate Tester (BERT)****Patterns Supported**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
All 1s	Yes	Yes	Yes	Yes
All 0s	Yes	Yes	Yes	Yes
1:1	Yes	Yes	Yes	Yes
1:7	Yes	Yes	Yes	Yes
M_OOS	Yes	Yes	Yes	Yes

**BERT Direction**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
Toward WAN 1	Yes	Yes	Yes	Yes
Toward WAN 2	Yes	Yes	Yes	Yes

**Tones Supported**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
300 Hz	Yes	Yes	Yes	Yes
1 kHz	Yes	Yes	Yes	Yes
3 kHz	Yes	Yes	Yes	Yes

**Tone Direction**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
Toward WAN 1	Yes	Yes	Yes	Yes
Toward WAN 2	Yes	Yes	Yes	Yes

**Signaling Manipulation****Toward WAN 1**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
300 Hz	Yes	Yes	Yes	Yes
1 kHz	Yes	Yes	Yes	Yes
3 kHz	Yes	Yes	Yes	Yes

**Toward WAN 2**

	<b>Voice Without Singaling</b>	<b>Voice With Singaling</b>	<b>Single Data DS0 (64Kbps)</b>	<b>Super-rate Data (Nx64Kbps)</b>
Set Transmit ABCD Signaling Bits	N/A	Yes	N/A	N/A
Monitor Status of Transmit ABCD Signaling Bits	N/A	Yes	N/A	N/A
Monitor Status of Receive ABCD Signaling Bits	N/A	Yes	N/A	N/A

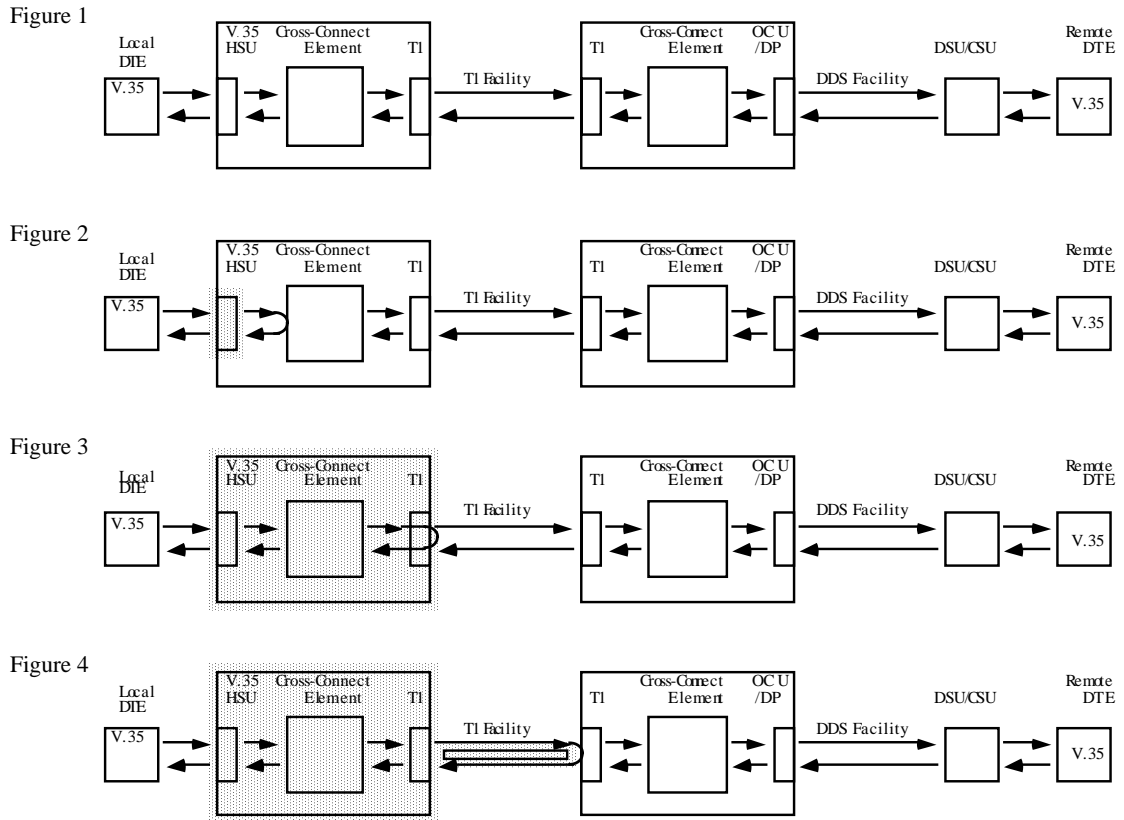
**Benefits of Built-In Diagnostics**

The real power of the integral diagnostics of the IMACS can be fully appreciated when the individual diagnostic tools are applied to everyday troubleshooting such as the one illustrated in the following example.

The environment shown in Figure 44 consists of two IMACS' connected by a T1 line. These are referred to as the Local IMACS and the Remote IMACS respectively. At the local IMACS, the DTE equipment is a co-located device providing a 56 Kbps V.35 interface that is connected to a V.35 HSU port. At the Remote IMACS, an OCU-DP card that interfaces to the 4-wire DDS tail-circuit extends the 56 Kbps to a third location. Consequently, the Remote IMACS is equipped with an OCU-DP card that interfaces to the 4-wire DDS tail-circuit. At the third location, the DDS circuit terminates in a generic, third party DSU/CSU that in turn provides a 56 Kbps V.35 interface to the remote DTE device.

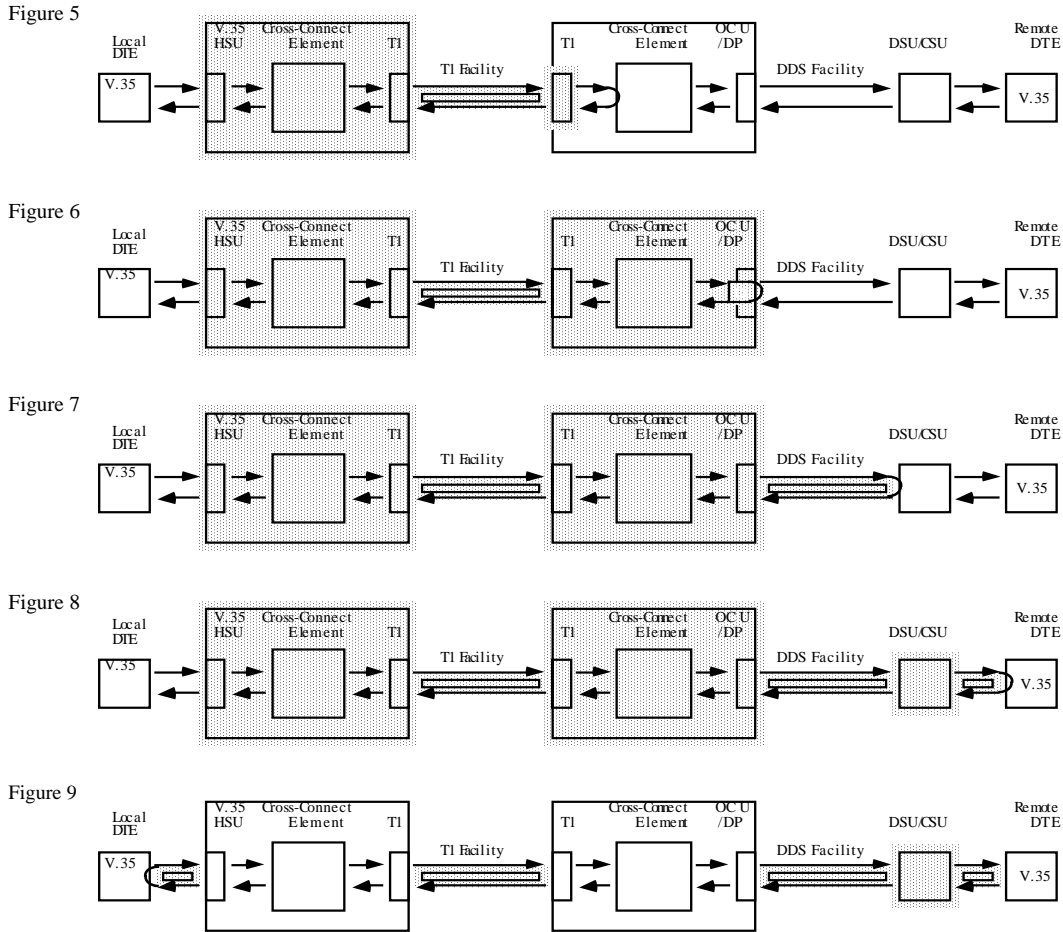
The system operator can use the diagnostic tool kit to systematically troubleshoot the problem on an end-to-end basis and to identify the faulty sub-system, even if it is external to the IMACS. One way to systematically troubleshoot the problem is illustrated in Figure 44. While there are many other approaches, in general, the procedure to follow is to combine loop backs that are generated either through software commands or via industry-standard loop-up codes with Bit Error Rate Tests (BERTs) for data circuits, or test tones for voice circuits. In the IMACS, all of those tools are available as integral features of the system and of the various cards. Each test determines if a specific sub-system is operating properly. In our example, after each test, the sub-systems that are shown to be functioning properly are shaded in gray.

In Figure 44, the local HSU card is put in Local loop back and a BERT test is run from the DTE. If successful, in Figure 44, diagnostics-figure 3, the loop back sequence is advanced by putting the T1 link of the Local IMACS in Local loop back and running BERT test again. This also tests the cross-connect element of the local IMACS if there is one present. In Figure 44XX, diagnostics-figure 4, the T1 link of the remote IMACS is configured in Line Loop back. Alternatively, a loop up code can be sent from the local IMACS to put the T1 link of the remote IMACS in Line loop back. This process is repeated until the remote DTE is put in network loop back and tested as shown Figure 44, diagnostics-figure 8.



**Figure 44a - Built-In Diagnostics Example**





**Figure 44b - Built-In Diagnostics Example**

**IMACS Performance Monitoring**

The IMACS provides non-intrusive performance monitoring of T1 lines and DDS circuits that terminate on OC U-DP cards. This capability is built into the system software and does not require any special options or expensive external equipment.

**T1 Line Performance Monitoring**

Performance monitoring, statistics gathering and performance reporting of T1 facilities is supported in the IMACS. In ESF format, CRC errors, Out-Of-Frame errors, and Controlled Slips are combined to provide line quality and performance statistics in accordance with industry standards. In D4 format, Bipolar Violations (BPVs) are used instead of CRC errors. The performance statistics are gathered and displayed in fifteen-minute intervals for the preceding twenty-four hours. They include Errored Seconds, Unavailable Seconds, Severely Errored Seconds, Bursty Errored Seconds, Loss Of Frame Count, and Slipped Seconds.

In ESF mode, these statistics are available to the system operator as well as to the carrier or service provider over the embedded 4 Kbps Facilities Data Link (FDL). Each ESF T1 facility can be independently programmed to support framing according to the AT&T 54016 standard or the ANSI T1.403 standard or both simultaneously. Additionally,

for each T1 in the system, the operator may select an error rate threshold (from 10E-4 to 10E-9) which, if exceeded, will cause the system to generate an Excessive Error Rate (EER) alarm.

### **DDS Line Performance Monitoring**

The two-port OCU-DP card supports two methods of non-intrusive error correction. The first is Majority Vote and applies to lower data rates such as 2.4, 4.8 and 9.6 Kbps. The other is the BCH method and applies to data rates of 19.2 Kbps and 56 Kbps.

If an OCU-DP port has error correction enabled, then the system will collect and display statistics on the performance of the circuit. Performance statistics include separate incoming (from the T1 network) and outgoing (to the 4-wire DDS circuit) Errored Seconds, Severely Errored Seconds and Consecutive Severely Errored Seconds and are displayed in one-hour intervals for the preceding twenty-four hours.

### **Frame Relay Performance Monitoring**

The Frame Relay Server accumulates performance statistics that can be used to monitor port, circuit and congestion characteristics. Statistics are gathered in 15-minute increments for a total of 24 hours. Collected statistics includes the:

- Circuit transmit and receive performance
- Circuit user contract compliance information
- Circuit congestion information
- Port transmit and receive information

### **ATM Performance Monitoring**

The ATM Server accumulates performance statistics used to monitor the DS3 physical link, the ATM UNI, and VBR and CBR circuit characteristics. Statistics are gathered in 15-minute increments for a total of 24 hours. Collected statistics include:

- DS3 ATM physical link performance in accordance with DS3 MIB specification
- ATM UNI performance in accordance with ATM Forum UNI 3.0 specification
- AAL 3, 4 and 5 performance in accordance with ATM MIB specification
- AAL 1 and corresponding CBR circuit performance in accordance with ATM Forum's DS1/E1 circuit emulation specification
- VBR circuit performance characteristics

### **Conclusion**

While the actual costs of telecommunications equipment has been decreasing over time, the cost associated with the logistical, operational and technical support keeping the network running is still expensive. As a result, it is critical that communications equipment provides all of the self-diagnostics and test tools needed to troubleshoot and resolve problems remotely, even if the problems are external to the equipment.

The Zhone Technologies IMACS combines the functionality of the most advanced integrated access device available on the market today. It is an important asset to the Zhone Technologies product portfolio, which incorporates the Zhone Technologies stamp of quality, innovation, engineering, quality assurance and HALT testing. The IMACS provides a full suite of network services such as frame relay, FXO, etc. to support a variety of user requirements. Furthermore, the IMACS' unparalleled integral test and diagnostic capabilities eliminate the need for external test equipment and in most cases, the need to dispatch personnel to troubleshoot problems.